CONNECTICUT RIVER ICE-JAM FLOOD CONTROL

COLEBROOK

MULTI - PURPOSE
DAM AND RESERVOIR
LOCAL PROTECTION

MOHAWK RIVER, COLEBROOK, NEW HAMPSHIRE

DETAILED PROJECT REPORT

(ADVANCE DRAFT)

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

MAY 1965

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASS. 02154

ADDRESS REPLY TO
DIVISION ENGINEER

REFER TO FILE NO. NEDED-D

26 May 1965

SUBJECT: Advance Draft - Detailed Project Report for Colebrook Multi-Purpose Dam and Reservoir, Mohawk River, Connecticut River Basin, Colebrook, New Hampshire

TO: Chief of Engineers
ATTN: ENGCW-P

1. There are submitted herewith, for review and comment, ten (10) copies of the revised Detailed Project Report for the Mohawk River, Colebrook, New Hampshire. Revisions have been made in light of comments contained in OCE 1st Indorsement dated 3 December 1964, Subject: "Advance Draft - Detailed Project Report for Colebrook Local Ice-Jam Flood Protection, Mohawk River, Connecticut River Basin, Colebrook, New Hampshire." Inclosed in the report for easy reference is a listing of those sheets which have been revised.

2. The roads thru Colebrook represent a major access into Canada and are heavily traveled by tourists. The number of motels, banks and other commercial establishments within the town relates the fact that the native population is increased substantially during the recreation season. The proximity of the Colebrook Dam adjacent to the local highways and but 1/2 mile north of the town should provide easy access and incentive for its use as a recreation area. Utilizing the Separable Cost Remaining Benefits Method, cost allocation studies indicate that recreation and flood control are economically justified as project purposes. State statistics support the need for additional recreation areas. The ice-jam flood project with its resulting stable pool provides the opportunity for a "project-related" recreational potential which could help satisfy this need and is consistent with planning for optimum range use of water resources. The inclusion of recreation as a project purpose is the most suitable and least costly of alternate considerations. A recreation Appendix F has been included in the report expanding upon this matter.

3. With reference to paragraphs in your basic letter of 3 December 1964, a copy of which is attached, specific replies to engineering review comments are noted as follows:

1a. An upstream impervious blanket of an additional 100' has been added to both the spillway and length of embankment.

1b. Low alkali cement will be specified for use in connection with materials from the Caledonia Sand and Gravel Company.

1c. It is noted that the concrete spillway design has been modified and new computation sheets incorporated in the Structural Appendix E. A check of the friction factor on the sloping base shows a coefficient of friction of .33. However, in addition to this, passive pressure can now be developed on the sloping base, producing a factor of safety greater than 1.5.

1d. Consideration has been given to alternative solutions at possible less cost, such as debris barrier type structure not involving concrete. These included the following methods located at the same alignment of the dam:

(1) Use of H-piling driven in two rows, 6' on centers across length of river. Estimated project cost $75,000.

(2) Timber crib rock-filled holding blocks set 14' on center in a staggered pattern. Estimated project cost $110,000.

(3) A low continuous timber crib weir planked and filled with stone. Estimated project cost $350,000.

(4) A timber crib weir and abutments as reported in Table 13 of the report designed to same heights as the recommended concrete proposals. Estimated project cost of $546,000.

Although other methods may offer some minor relief, they will not impound frazil ice as desired by the ice engineering specialist of the CRREL laboratories, and as elaborated upon in Section P, paragraphs 37-39 of the report. Of the alternatives noted above number (4) offers only positive control of the ice problem. Because of the higher maintenance cost inherent with timber designs and their shorter life expectancy, it is believed that the concrete design, reported in Table 8 of the report, is the more favorable and in the long run most economical design. In this connection attention is invited to review comment, 1st Ind, 27 Nov 62, from OCE to NED memo of 3 Oct 62, recommending consideration of concrete design.

NEDED-D 26 May 1965

SUBJECT: Advance Draft - Detailed Project Report for Colebrook Multi-Purpose Dam and Reservoir, Mohawk River, Connecticut River Basin, Colebrook, New Hampshire

2. We have utilized ER 1165-2-6 in evaluating area redevelopment effects and Appendix B has been revised accordingly.

3. Recreation development benefits have been reduced from $1.00 per annual visitor day to $0.75.

4. The annual operation cost of $1,500 provides for the services of one full time lifeguard over the 10 week recreation period who will also manage and maintain the area.

4. Local cost sharing is estimated at $42,000 as noted in Table 12 of the report. Town officials would be notified of the proposed changes in cost sharing developed by reason of inclusion of recreation as a project purpose, and as developed in accordance with ER 1165-2-4 (12 Jan 65), pending approval and authorization of contract plans.

5. Plans and specifications would be prepared substantially in accordance with the Detailed Project Report, as approved. Recommend authorization of funds in the amount of $47,000 for preparation of plans and specifications. Construction funds in the amount of $602,000 would be requested upon completion of contract plans and specifications and the receipt of bids.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN Wm. LESLIE
Chief, Engineering Division

2 Incl
1. Report (10 cys)
2. Cy OCE ltr dtd 12/3/64

Revised Pages
for
ADVANCED DETAILED PROJECT REPORT

MOHAWK RIVER
COLEBROOK, NEW HAMPSHIRE

Main Report

Cover
3-page Letter of Transmittal
1st Indorsement, OCE, 3 Dec 64 (4 pgs)
Insert Cover Sheet
i of Detailed Project Report

iii	"	"		"	"
iv	"	"		"	"
v	"	"		"	"
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Appendices

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APPENDIX "E"
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Plate No. F-1

ENGCW-PD (31 Mar 64) 1st Ind
SUBJECT: Advance Draft - Detailed Project Report for Colebrook Local Ice-Jam Flood Protection, Mohawk River, Connecticut River Basin, Colebrook, New Hampshire

HQ, DA, CofEngrs, Washington, D. C. 20315, 3 December 1964

TO: Division Engineer, U. S. Army Engineer Division, New England
WALTHAM, MASSACHUSETTS 02154

1. Project formulation criteria provide that the scale of individual projects, each purpose or segment thereof, and each element, segment and purpose of multiple-purpose projects and programs must, among other things, be more efficient in the use and production of economic resources than any other actual or potential available means, public or private, of meeting those specific needs, which will be displaced or precluded from development by the project or program. The criteria further provide for a maximum excess of benefits, tangible and intangible, over costs. (See EM 1120-2-101, para. 1-83).

2. The data presented show that the proposed dam is not justified for flood protection alone. Accordingly, inclusion of the flood control function will be justified only if the cost of adding it to recreational development would be less than the additional benefits which would accrue. The report does not provide specific data on the cost of single purpose recreational development. However, there are many undeveloped lakes in the area which apparently would be suitable for recreation if access is provided. Thus, it is likely that recreation could be provided at a cost which would preclude economically justified addition of flood control. Stated in another way, it appears that maximum net-benefits would be obtained by an alternative single purpose recreation development based on providing access to an existing undeveloped lake. In view of the foregoing it is concluded that the project as now proposed fails to meet the requirement of economic justification, and Federal participation does not appear warranted.

3. As a matter of information, review comments on other aspects of the report are inclosed. Particular attention is called to the suggestion that further consideration be given to alternative solution at possible less cost, such as a debris barrier type structure not involving expensive concrete work.

FOR THE CHIEF OF ENGINEERS:

R. J. B. PAGE
Colonel, Corps of Engineers
Acting Director of Civil Works

1 Incl
1. Draft 4 cys w/d
Added 1 Incl
2. Review Comments

Review Comments on Advance Draft
Detailed Project Report for Colebrook Local Ice-Jam
Flood Protection, Mohawk River, Connecticut River
Basin, Colebrook, New Hampshire

1. Engineering review comments are as follows:

a. Although the proposed structure is low, the foundation is pervious to semi-pervious and no cut-off is provided; therefore, an upstream impervious blanket of an additional 100 feet should be added to both the spillway and embankment.

b. Appendix D, Para 9e, Page D-10. Low alkali cement should be specified for use in connection with materials from the Caledonia Sand and Gravel Company owing to the presence of phyllite and in the absence of complete data on potential alkali reactivity.

c. Pages DM-1 and DM-6 of Computations. The assumption of an allowable sliding value of 0.57 is not concurred in. This appears to be more likely to represent the true tangent phi value of the material described. Since concrete structures on a cohesionless material should have a minimum safety factor, in sliding, of 1.50 the maximum allowable sliding ratio should not exceed 0.38. Assuming an actual tangent phi of 0.57, the safety factor for an actual sliding ratio of 0.52 is only 1.10.

d. It is suggested that further consideration be given to alternative solutions at possible less cost, such as a debris barrier type structure not involving expensive concrete work.

2. Future evaluation of area redevelopment effects should be in accordance with ER 1165-2-6.

3. The benefit figure estimated for the recreation development appears excessive. Reference is made to "Evaluation Standards for Primary Outdoor Recreation" by the Ad Hoc Water Resources Council, dated 4 June 1964. As noted therein, the estimate of the pattern of annual use should be based on factors affecting the extent of use. Factors in this case such as the limited population (Colebrook 2,390 people and only 14,600 people within a 25 mile area); limited recreation use potential; and other recreation opportunities, would modify the potential annual use. The unit value for a recreation day should reflect the quality of activity and the degree to which opportunities are provided to engage in a number of activities. In view of the limited activities provided, it would appear more appropriate to use a recreation day unit value on the order of 50¢ per day. In this connection it is noted that the letter, dated 25 March 1964, from the Board of Selectman states "There is no public bathing within 26 miles of Colebrook. The cost to use the private

pool is 50¢ per day per child. Not many families can afford that much for bathing." It would appear this alternative facility cost would also tend to limit the value used for a recreation day.

4. The maintenance estimate for the recreation feature does not appear to reflect the services of a lifeguard or any replacement costs.

5. In view of the limited scope of recreation facilities offered most of the visitors to the recreation development would likely be from the immediate area. The usage computation reflects this localized benefit offered by the facility. Thus, in many respects it would appear the proposed recreation facility would be similar to a municipal park which normally would be provided as a local responsibility.

CONNECTICUT RIVER ICE-JAM FLOOD CONTROL

COLEBROOK

LOCAL PROTECTION PROJECT

MULTI-PURPOSE DAM AND RESERVOIR

MOHAWK RIVER, COLEBROOK, NEW HAMPSHIRE

DETAILED PROJECT REPORT

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND

CORPS OF ENGINEERS WALTHAM, MASS.

MAY 1965

R 5/26/65

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COLEBROOK

LOCAL ICE PROTECTION PROJECT

MOHAWK RIVER - CONNECTICUT RIVER BASIN

COLEBROOK, NEW HAMPSHIRE

MARCH 1964

A. PERTINENT DATA

1. Purpose:	Ice-jam flood protection of Mohawk River in the business section of the town.
2. Location:	Mohawk River, Colebrook, Coos County, New Hampshire.
3. Type of Improvement:	Upstream dam and reservoir for ice retention, with downstream channel improvements and realignment at two locations in the vicinity of the Connecticut River confluence. Project includes an orifice-type fishway and a day-use, park-type recreation development including facilities for swimming and picnicking.
4. Hydrology:	Project design flood = 15,000 c.f.s. Drainage area = 48.0 sq. mi. at ice retention dam.
5. Colebrook Dam:	Dam - Earth fill 790 feet long, maximum height 22 feet, top elevation 1054 m.s.l., 12 foot top width, 1 vertical on 4 horizontal upstream, 1 vertical on 3 horizontal downstream, topsoil and seeded side slopes above elevation 1046, rock slope protection below elevation 1046. Concrete Spillway - 215 feet long, crest elevation 1044, gated draw-down invert elevation 1037, stilling basin elevation 1029.5, height of spillway 18.5 feet, maximum head 7 feet, orifice-type fishway adjacent to north abutment. North and south abutments - L-shaped, 28.5 feet high, top elevation 1054.

Pertinent Data, Cont.

6. Principal Quantities:

Concrete	6,550 C.Y.
Excavation	52,800 C.Y.
Earth fill	32,100 C.Y.
Rock Slope Protection	5,300 C.Y.
Gravel Bedding	2,800 C.Y.

7. Recreation Development: Includes parking area for 65 cars, 140 feet of beach development, 1-pit-toilet and change house, 24 picnic tables and 12 fireplaces.

8. Cost Estimates:

First Costs

Federal	$649,000
Non-Federal	42,000
Total	$691,000(1)

Annual Costs

Federal	$ 24,900
Non-Federal	5,400
Total	$ 30,300

(1) Exclusive of pre-authorization costs of $46,000.

9. Benefits:

Average annual benefits	$32,700
Benefit cost ratio	1.08 to 1.0

B. PROJECT AUTHORITY

This Detailed Project Report is submitted pursuant to authority contained in Section 205 of the 1948 Flood Control Act, as amended by Section 212 of the Flood Control Act of 1950, Public Law 685, 2nd Session, 84th Congress, adopted 11 July 1956; and Section 205 of Public Law 87-874 of the Flood Control Act of 1962 approved 23 October 1962. Further authority is contained in 1st Indorsement dated 3 December 1964 from Chief of Engineers to Advance Draft submitted by NED in March 1964, and 1st Indorsement dated 27 November 1962 and 3rd Indorsement of 6 June 1963 from the Chief of Engineers to a report dated 3 October 1962 from the Division Engineer, New England Division, Subject: "Reconnaissance Report, Local Protection Project, Mohawk River, Colebrook, New Hampshire."

C. SCOPE OF DETAILED PROJECT REPORT

1. SCOPE

This Detailed Project Report reviews the ice-jam flood problem on the Mohawk River in Colebrook, New Hampshire, caused by the formation of anchor ice downstream of Main Street and by the resulting jamming of moving sheet ice on the Mohawk River. It submits a definite project plan of improvement which includes the construction of a concrete spillway and earth-fill type dam located about one-half mile upstream of the Main Street bridge; channel deepening and realignment downstream of the Main Street bridge; an orifice-type fishway; and a day-use, park-type recreational development including facilities for swimming and picnicking utilizing the 14-acre permanent pool surface provided by the project.

2. TOPOGRAPHIC SURVEYS

A topographic survey of the proposed local protection project on a scale of 1" = 40' and a contour interval of one foot was made in November 1962 and July 1963.

3. SUBSURFACE EXPLORATIONS

Geological reconnaissance of the proposed project area has been made. Subsurface explorations were performed during November 1962 and consist of core borings and hand probings. The location and description are shown on Plates 2 and 3. Investigations which are delineated in detail in Appendix D, reveal no particular soil problems in the area of proposed improvements.

4. ECONOMIC INVESTIGATIONS

A survey of flood damages in Colebrook was made during April 1962. The survey consisted of a field examination of the project area and personal interviews with town officials and with property owners affected by ice-jam flooding. Damage surveys revealed that although the 1929 flood created the greatest damage due to upstream dam failures, the town is primarily concerned with damages resulting from frequent ice-jam flooding that has occurred with such consistency in the past 15 years, that it was difficult for the townspeople to determine which flood brought the highest stages. Also, an investigation of economic developments and trends was made to project potential future growth and needs relevant to the project.

5. REAL ESTATE STUDIES

Field reconnaissance and conferences with local officials were used as the basis for real estate costs. Details of real estate estimates are presented in Section T.

6. CONFERENCES WITH LOCAL OFFICIALS

Close liaison has been maintained with town and state officials and other interested parties. Desires of local interests are described in Section O. Officials of local concerns have been contacted and the plan of protection explained. All have expressed a strong desire for the immediate construction and completion of the proposed project. Local interests have supplied firm statements as to their willingness and ability to participate in the proposed improvement. Formal assurances will be furnished by the Town and the State of New Hampshire prior to completion of final design.

D. PRIOR REPORTS

7. RECONNAISSANCE REPORT

In response to requests from local interests and in compliance with ER 1165-2-102, a reconnaissance report on ice-jam flooding in Colebrook, New Hampshire, was made. The report stated that construction of a rock-filled timber crib spillway and earth-fill dam with other channel improvements would relieve the situation. The reconnaissance report indicated that the project was economically feasible and within the scope of Section 205, Public Law 87-874. It recommended that the New England Division be authorized to prepare a Detailed Project Report. By 1st Indorsement dated 27 November 1962, the Chief of Engineers authorized preparation of a Detailed Project Report and suggested consideration of a concrete spillway structure in lieu of the timber structure.

An advance copy of the Detailed Project Report was submitted on 31 March 1964. The Chief of Engineers suggested consideration of alternate solutions and studies regarding recreation and also made engineering comments as per 1st Indorsement dated 3 December 1965.

E. DESCRIPTION OF AREA

8. GEOGRAPHY

The Town of Colebrook is located in northern New Hampshire about 10 miles south of the Canadian border, 225 miles north of Boston, Massachusetts and less than one mile from the Vermont-New Hampshire state line. The Mohawk River originates at Lake Gloriette in Dixville, New Hampshire and flows in a westerly direction through the Town of Colebrook discharging into the Connecticut River about one-half mile west of the center of town. The river flows for a distance of about 11 miles with a drop of 850 feet. It is fed by North Branch, Beaver Brook and several mountain streams and brooks which produce a combined drainage area of 61 square miles. The Mohawk River passes under three highway bridges within the town, namely, Main Street, Pleasant Street and Parson Street. About one-fourth mile downstream of the Main Street bridge the river passes under a railroad bridge owned by the Maine Central Railroad. From the railroad bridge to the Connecticut River the Mohawk River channel meanders for about one-third mile through pasture lands.

9. TOPOGRAPHY

The Mohawk River is located in a region of moderate to high relief in the White Mountains section of New England. Except in the mountainous headwaters reaches, the river flows through a region which is more typical of the New England Upland with moderately high hills and relatively wide valleys. It is mainly a maturely dissected region of moderate relief which has been considerably modified by glaciation. The hills are generally rounded and thinly blanketed by till. The main valleys which are relatively wide and open, are deeply filled with outwash which occurs in flat valley plains and terrace deposits on the valley sides. The bedrock of the region consists of closely folded crystalline rocks, mainly philite, slate and schist. Outcroppings are noted occasionally through the till and outwash on the lower flanks of the valleys and at higher elevations on the sides and crests of the hills where they occur in numerous and extensive areas.

10. SURFICIAL SITE GEOLOGY

At the dam site State Highway No. 26 runs along the top of a steep-faced terrace which rises abruptly from the edge of the stream channel and extends northward in a broad, flat plain to the far valley wall. The river occupies a very shallow channel along the northern side of the wide valley bottom. The surface of the valley bottom rises gently southward from the stream undulating in low ridges and irregular swells to the foot of the high but narrow terrace which extends upstream from the base line along the south side of the valley. The overburden in the terraces is mainly outwash consisting of variable stratified sands and gravels. In the valley bottom the outwash is partly buried beneath alluvial materials. The right abutment is partly wooded with brush and scattered trees. The valley bottom is mainly overgrown grassland with scattered clumps of trees. A thick growth of alders occupies a seasonally marshy area along the foot of the left abutment which is densely wooded with spruce.

11. MAIN RIVER AND TRIBUTARIES

a. Main River - The Mohawk River originates at Lake Gloriette in Dixville, New Hampshire, flows in a westerly direction through the Town of Colebrook, and discharges into the Connecticut River about one-half mile west of the center of town. The drainage area at the mouth of the river is 61 square miles. From Lake Gloriette the river drops about 850 feet in its length of 11 miles. The East, West and North Branches are the principal tributaries.

b. Tributaries -

(1) East Branch - The drainage area of the East Branch is about 10 square miles. It is a precipitous mountain stream and falls about 1160 feet over its 4.3 miles of length.

(2) West Branch - The West Branch joins the East Branch about a mile upstream of Kidderville and has a drainage area of about six square miles. It falls about 960 feet from Mugget Mountain to the confluence, a distance of 5.8 miles.

(3) North Branch - The North Branch joins the Mohawk River within the Town of Colebrook, downstream of the major damage area. Including its principal tributary, Beaver Brook, it has a drainage area of 10.5 square miles. The total fall is about 980 feet over its length of 14.8 miles.

12. STREAM CHARACTERISTICS

The Mohawk River and its tributaries are typical mountain streams and have a very flashy runoff characteristic. Major floods at Colebrook have resulted from either upstream dam failures or sudden breakup of the ice cover which has been carried downstream and piled up at bridges and other constrictions. Although the channel through Colebrook apparently has a reasonably high capacity for storm runoff during the non-ice season, the potential for ice-jam flooding is present every year.

13. MAPS

The Mohawk River Basin, including the site of the proposed local protection project, is shown on Department of the Interior, U. S. Geological Survey Maps for Colebrook, New Hampshire indexed as Dixville Quadrangle, New Hampshire (scale 1:62,500) and Averill Quadrangle, New Hampshire (scale 1:62,500). The Mohawk River Basin is noted on Plate No. 1 accompanying this report.

F. CLIMATOLOGY

14. GENERAL

The Mohawk River Basin has a variable climate characterized by frequent but generally short periods of heavy precipitation. The basin lies in the path of the "prevailing westerlies" and is exposed to the cyclonic disturbances that cross the country from west or southwest toward the east or northeast. The area is also subject to coastal storms that travel up the Atlantic seaborad in the form of hurricanes of tropical origin or storms of extratropical nature, often called "northeasters". The winters in the basin are moderately severe with mean annual snowfall near 100 inches and temperatures in the minus "forties" having been recorded. The spring melting of the winter snow cover occurs generally in the months of April and May.

15. TEMPERATURE

The average annual temperature of the Mohawk River Basin is about 40°F. Based on records at Lemington, Vermont, about five miles south of Colebrook, New Hampshire, extremes of temperature have varied from -43°F to 95°F. Table I shows the monthly mean, maximum, minimum and annual temperatures at Lemington, Vermont, elevation 1015 feet mean sea level.

TABLE I

MONTHLY TEMPERATURES

(Degrees Fahrenheit)

Lemington, Vermont
Elevation 1015 feet msl
(13 Years of Record)

Month	Mean	Maximum	Minimum
January	14.0	62	-42
February	16.8	54	-43
March	26.1	78	-32
April	38.6	83	-12
May	50.1	87	17
June	59.8	92	24
July	65.0	95	34
August	62.9	94	32
September	55.1	89	17
October	45.5	85	12
November	33.5	74	-11
December	17.5	61	-37
ANNUAL	40.5	95	-43

16. PRECIPITATION

The average annual precipitation over the Mohawk River watershed varies from about 44 inches at the mouth to about 38 inches in the headwaters. The mean, maximum and minimum monthly and annual recorded precipitation at Lemington, Vermont and Dixville Notch, New Hampshire which are representative of the mouth and upper watershed, respectively, are summarized in Table 2.

17. SNOWFALL

The mean annual snowfall over the Mohawk River watershed is 102 inches, based upon records for Lemington, Vermont and Dixville Notch, New Hampshire which are summarized in Table 3. The water equivalent of the snow cover reaches a maximum depth about the middle of March which is often over seven inches.

TABLE 2

MONTHLY PRECIPITATION RECORD

(In Inches)

Lemington, Vermont
Elevation 1015 feet msl

Month	Mean	Maximum	Minimum
January	2.10	3.29	.81
February	1.94	3.63	.70
March	2.04	3.86	.71
April	2.90	4.26	.94
May	4.12	9.34	1.72
June	4.78	8.84	2.43
July	3.84	9.52	1.26
August	3.80	6.28	1.09
September	3.71	7.68	1.37
October	3.14	4.99	1.33
November	3.61	5.79	1.37
December	2.57	4.71	1.07
ANNUAL	38.44	50.24	30.78

DIXVILLE NOTCH, NEW HAMSPHIRE
Elevation 1650 feet msl

Month	Mean	Maximum	Minimum
January	3.10	5.84	1.04
February	2.70	5.76	1.26
March	3.14	7.93	1.04
April	3.32	6.14	.92
May	3.99	8.04	2.01
June	5.05	8.50	2.26
July	4.44	8.90	1.52
August	4.03	10.22	1.13
September	4.29	11.27	1.57
October	3.76	8.31	1.33
November	3.89	8.47	.85
December	2.86	5.74	1.14
ANNUAL	44.51	62.92	33.92

TABLE 3

MEAN MONTHLY SNOWFALL
(Average Depth in Inches)

Lemington, Vermont
Elevation 1015 feet msl

Month	Snowfall	Month	Snowfall
January	22.5	July	T
February	22.4	August	0
March	15.8	September	T
April	4.3	October	1.6
May	.5	November	11.1
June	T	December	18.7

ANNUAL = 97.9

DIXVILLE NOTCH, NEW HAMPSHIRE
Elevation 1650 feet msl

Month	Snowfall	Month	Snowfall
January	22.2	July	T
February	21.6	August	0
March	18.0	September	T
April	9.4	October	2.1
May	1.2	November	11.5
June	T	December	16.6

ANNUAL = 106.1

18. STORMS

The Mohawk River Basin is subjected to storms of continental origin which move easterly or northeasterly across the country under the influence of the "westerlies" and to maritime storms which move northward along the Atlantic seaboard, some of which are of tropical origin. Critical flood conditions at Colebrook are seldom produced by storms alone, but are the result of a rapid "break up" of the ice and concurrent high river flow which may be from snowmelt supplemented by rainfall. Potential flood conditions are present about every spring.

Periods of moderate springtime precipitation occur frequently over the upper Connecticut River basin as is evidenced by Table 4 of recorded storms at Bloomfield, Vermont.

TABLE 4

SPRINGTIME STORMS

Bloomfield, Vermont
Elevation 940 feet msl
Period of Record 54 years

Date of Storm	Precipitation (inches)
14-15 April 1909	1.88
25-28 May 1910	3.00
29 April - 1 May 1912	3.75
24-28 March 1913	3.15
10-14 May 1918	2.25
15-16 May 1929	0.97
25 April 1934	2.01
12-23 March 1936	5.24
13-20 May 1937	3.87
17-21 May 1940	2.73
30 March - 3 April 1951	2.18
4-6 April 1960	1.85

G. RUNOFF AND STREAMFLOW

19. DISCHARGE RECORDS

There are no published records of streamflow in the Mohawk River and as far as can be learned no estimates of peak discharge have been made. The U. S. Geological Survey has published records of river stage and discharge for several streams in the vicinity of Colebrook, New Hampshire. In Table 5 are summarized the records from seven locations in the upper Connecticut River Basin.

TABLE 5

STREAMFLOW RECORDS

Location of Gaging Station	Drainage Area (sq.mi.)	Period of Record	Discharge (cfs) Mean	Maximum	Minimum
Connecticut River at First Connecticut Lake near Pittsburg, N. H.	83.0	1917-61	195	7,200	3.1
Connecticut River below Indian Stream near Pittsburg, N. H.	254	1956-61	558	4,580	34
Upper Ammonoosuc River near Groveton, N. H.	232	1940-61	477	9,950	32
East Branch Passumpsic River near East Haven, Vt.	53.8	1939-45 1948-61	102	2,200	13
Moose River at Victory, Vt.	75.2	1947-61	140	2,940	3.7
Ammonoosuc River at Bethlehem Junction, N.H.	87.6	1939-61	210	10,800	16
Wells River at Wells River, Vermont	98.4	1940-61	140	3,230	5.1

20. RUNOFF

The average annual runoff is 2.06 csm in the Upper Ammonoosuc River near Groveton, New Hampshire is considered typical of the Upper Connecticut River Basin and the Mohawk River. The mean, maximum and minimum annual and monthly runoff near Groveton, New Hampshire is shown in Table 6.

TABLE 6

AVERAGE RUNOFF

Upper Ammonoosuc River near Groveton, New Hampshire
(cubic feet per second per square mile)
(1941-61)

Month	Maximum	Minimum	Mean
October	3.02	0.30	1.21
November	4.37	0.51	1.98
December	4.24	0.30	1.46
January	2.26	0.23	0.99
February	1.34	0.28	0.82
March	5.91	0.32	1.90
April	10.42	3.74	6.47
May	8.31	1.73	4.93
June	4.80	0.77	4.35
July	1.92	0.51	1.03
August	2.09	0.34	0.73
September	6.14	0.22	0.99
Annual	3.00	1.41	2.06

H. FLOODS OF RECORD

21. FLOOD OF RECORD

According to local reports the greatest known flood on the Mohawk River at Colebrook, New Hampshire occurred in May 1929 and was caused primarily by the failure of two privately owned dams. The lakes formed by the dams, known locally as Abernaki and Coashauk, were located about 13 miles upstream of Colebrook. Heavy rainfall combined with melting snow overtaxed the dams which failed, releasing a flood wave down the river.

During the 50-year period prior to 1930 it is reported that at least six noteworthy floods occurred. However, little or no detailed data are available as to their relative magnitudes or depths of flooding. Since 1930 there has been no important flooding from runoff alone but damage from ice-jams has become a common springtime occurrence. The frequency of ice-jam flooding has increased since 1945 to about once every two years. Local residents attribute this increase to the abandonment of upstream dams which previously retarded the spring "break up" by temporarily storing cover ice and apparently discouraged the movement of frazil ice.

22. ICE-JAM FLOOD DEVELOPMENT

Owing to the complexities of the ice-jam problem and its solutions technical assistance was provided by specialists from the U.S. Army Cold Regions Research and Engineering Laboratory at Hanover, New Hampshire. Attention is invited to Technical Memorandum by Dr. A. Assur which is attached as a Supplement to Appendix C.

I. FLOOD FREQUENCIES

23. FREQUENCY OF FLOODS WITHOUT ICE

Discharge-frequency relationships, shown on Plate No. 8, were determined for the Mohawk River at Colebrook from a regional analysis of the Upper Connecticut River Basin developed by procedures set forth in ER 1110-2-1450 dated 10 October 1962. Only limited recorded data concerning past flood flows in the Mohawk River, an ungaged stream, are available because of the loss through fire of town records.

24. STAGE-FREQUENCY CURVE OF ICE-JAM FLOODING

Stage frequency relationships, shown on Plate No. 9, were estimated for economic analysis from flood information furnished by owners of property adjacent to the Mohawk River in Colebrook. Records from other rivers within the Division indicate that ice-jams can raise normal water levels several feet. There appears to be little or no correlation, however, between natural river discharges and ice-induced stages because of the complicated factors which produce ice-jam flooding. Principal among these factors are: the thickness and conditions of the ice; the rate at which the spring break-up occurs; and the constrictive effects of local structures within the river channel. In recent years ice-jam flooding has become about a biennial event in the reach between Parsons Street and the confluence of the North Branch. It is the general belief that this is due to the abandonment of upstream dams which previously prevented an unrestricted flow of ice downstream.

J. STANDARD PROJECT FLOOD

Derivation of a standard project flood to measure the effectiveness of the dam and reservoir was not considered applicable for this type of project. However, a standard project flood was developed and used as a design criteria for the spillway, as described in the following paragraphs.

K. SPILLWAY DESIGN FLOOD

25. GENERAL

After careful consideration of the small storage capacity, low spillway crest, and relatively high tailwater, it was concluded that an all-season standard project flood was a sufficiently severe criterion for the determination of spillway requirements. Standard project storm rainfall was derived by procedures described in Civil Works Bulletin 52-8. A three-hour synthetic unit hydrograph was adopted from analysis of other river basins having similar runoff characteristics because of the meager flood data available for the Mohawk River.

26. SPILLWAY DESIGN FLOOD

The all-season standard project storm rainfall for the 48-square mile watershed above the dam site totaled 9.8 inches for 24 hours. Infiltration and other losses were assumed at a rate of 0.20 inches per three-hour period, resulting in rainfall excess of 8.3 inches. The rainfall excess was applied to the adopted unit hydrograph which was derived from the following selected unit graph coefficients:

$$\begin{aligned} q_p &= 40 \text{ csm} \\ T_p &= 5.5 \text{ hours} \\ C_t &= 1.3 \\ 640\ C_p &= 220 \\ W_{50} &= 11.4 \text{ hours} \\ W_{75} &= 7.5 \text{ hours} \end{aligned}$$

The resulting standard project flood hydrograph had a peak discharge of 15,200 cfs. The estimated frequency of this discharge is 0.15 percent chance of occurrence in any one year, or an average of once in approximately 700 years.

27. SPILLWAY DESIGN FLOOD DISCHARGE

Surcharge storage above the spillway crest is very small and its minor modifying effect would result in a spillway design flood discharge of 15,000 cfs.

28. SPILLWAY DESIGN FLOOD WITH SNOWMELT

The selected spillway design flood does not include runoff from snowmelt. A study of hydrologic records shows that although a spring storm combined with snowmelt would produce a flood having a somewhat greater volume than the all-season storm, the flood peak would be lower. The Colebrook pool will have only a minor amount of surcharge storage so that peak flow is a much more severe criterion than flood volume.

L. FLOOD DAMAGE AND ECONOMIC DEVELOPMENT

29. EXTENT AND CHARACTER OF FLOODING

During the past 15 years, ice-jams occurring in the shallow river bed downstream of the Main Street bridge in the center of Colebrook have caused frequent spring flooding of about 18 acres of residential, public and commercial properties along both banks of the Mohawk River. A typical ice-jam starts below the Main Street bridge and results in further upstream jamming, causing the river to overflow and flood about six acres on the left bank and about 12 acres on the right bank to depths of two and one-half feet. At slightly higher stages than a typical ice-jam flood, approximately 25 acres on the right bank and six acres on the left bank would be inundated. The value of land and improvements in the flood area are estimated to be in excess of $500,000.

30. FLOOD DAMAGES

The flood of March 1960, which was a typical ice-jam flood on the Mohawk River, caused damages estimated at $12,500 to residential, commercial and public properties. Property owners experienced basement flooding to depths of two and one-half feet which resulted in stock losses and required repairs to heating units and clean up. Flood stages slightly higher than those experienced in the March 1960 flood would flood additional properties and cause substantial increases in losses.

31. RECURRING AND PREVENTABLE LOSSES

A recurrence of a typical ice-jam flood similar to the March 1960 flood on the Mohawk River, would cause damages estimated at $12,500 to properties in Colebrook. A flood two feet higher than a typical flood would cause damages estimated at $85,000 in the flood area. Construction of the recommended project would eliminate all losses from floods at a 100-year frequency or less.

32. AVERAGE ANNUAL LOSSES

Damage-frequency curves were developed using recurring stage-damage and stage-frequency relationships and resulted in estimated annual losses of $18,200, under present pre-project conditions for storms more frequent than a 100-year storm. Construction of the project would eliminate all of these annual losses.

33. TRENDS OF DEVELOPMENT

Colebrook, with a population of 2,389 in 1960, is the fifth largest town in Coos County. The population increase of 12.9 percent over the last decade was one of the highest in Coos County and approximates the increase of 13.8 percent for the State of New Hampshire. U. S. Route 3, a major north-south highway in New Hampshire, passes through Colebrook and tourists driving to Canada contribute to the economy of the town. The natural beauty of the area has also attracted vacationing tourists and an increase in tourist trade is expected over the life of the project. Past and present land use in Colebrook has been such that little growth or change in use which would result in increased losses seems probable.

34. ESTIMATES OF BENEFITS

Average annual flood damage prevention benefits, taken as the difference between average annual losses under existing conditions and those remaining after construction of the project, amount to $18,200. Average annual redevelopment benefits obtained from the utilization of the labor force of Colebrook amount to $4,000. It is not anticipated that the project will result in any increased utilization or enhancement benefits. Details of the derivation of benefits are set forth in Appendix B.

M. EXISTING CORPS OF ENGINEERS FLOOD CONTROL PROJECTS

There are no existing Corps of Engineers flood control projects in the Mohawk River basin.

N. IMPROVEMENTS BY FEDERAL AND NON-FEDERAL AGENCIES

35. FEDERAL IMPROVEMENTS

There are no Federal improvements within the Mohawk River watershed.

36. STATE AND LOCAL IMPROVEMENTS

An ice-barrier consisting of three concrete blocks measuring six and one-half feet by eight feet located about 2500 feet upstream of the Parson Street bridge, was constructed by local interests. The concrete blocks, however, have only provided limited effectiveness in holding cover ice upstream of the built up limits of the town.

In an attempt to alleviate ice-jam flooding downstream of the Main Street bridge, the Town of Colebrook expended about $2,000 for channel improvements which were accomplished during the summer of 1961. The work consisted of channel clearing, widening and realignment of two sharp bends in the stream. Thirteen hundred linear feet of channel was improved and widened from 50 to 100 feet with slopes of 1 vertical to 2 horizontal.

In the spring of 1962 three sections of concrete retaining wall located upstream of the Main Street bridge were constructed by the Town of Colebrook with the aid of the New Hampshire Water Resources Commission. Failure of the walls could have negated channel improvement measures, as well as further aggravate the ice-jam problem. Local interests stated this as one of the reasons for making the restoration. The three wall sections which totaled about 175 feet in length had an estimated construction cost of about $10,000.

The Town of Colebrook is planning to construct additional sewage facilities which include a treatment system in the vicinity of our downstream channel improvement work. A new pumping station is proposed near the railroad bridge. Two force mains will cross the river in this same vicinity about 750 feet downstream of the Main Street bridge. Adequate pipe cover will be provided so as not to interfere with any future channel excavations. The proposed sewer works are shown on Plates No. 6 and 7.

O. IMPROVEMENTS DESIRED

Several meetings have been held with local interests to determine the feelings of townspeople and local officials towards the proposed plan of flood control. The citizens of the town are desirous of preventing future losses from ice-jam flooding along the Mohawk River and feel that the proposed plan, as outlined herein, will adequately reduce future damage potential. Local interests have expressed a willingness to fully cooperate on this proposal for flood protection and have expressed a desire that recreation facilities be incorporated in the project. Prints of letters giving the views of local interests are included in Appendix A of this report.

P. FLOOD PROBLEM AND SOLUTIONS CONSIDERED

37. GENERAL

Frequent ice-jam flooding causes damages at Colebrook during the spring freshet season. On such occurrences large quantities of floating river ice (frazil-ice) are transported to the low-lying restricted channel area located about 600 feet downstream of the

Main Street bridge. In this area frazil-ice adheres to the channel bottom and forms layers of anchor-ice, reducing channel depths and transportation capabilities of the river. The cover ice which makes its way downstream during spring freshets, or floods, is then deposited upon the anchor ice. This process, when repeated, results in an ice-jam. The river backs up from the intensifying ice-jam, and water and ice overflow the river banks, thus flooding the center of town. The capacity of the river channel at Colebrook is adequate for usual flood flows without ice, as evidenced by the fact that there have been no such floods on the Mohawk River since May 1929. As previously noted, this record flow was caused primarily by the failure of two upstream dams which have not been replaced. Local interests report that there has been an increase in the number of jams experienced since 1929. It is significant to note the fact that only one ice-jam flood occurred prior to 1882. There is strong evidence that the loss of upstream dams has removed the retention affect of frazil-ice which currently accumulates in the vicinity of the Main Street bridge.

38. ICE CONDITIONS

Ice conditions are a major factor in the region of the Mohawk River. Surface ice also referred to as sheet or cover ice, generally forms 18 to 24 inches thick on the upper river, its tributaries and on the lakes or other quiet areas within the basin during the winter months. The nature of the drainage area is such that it is very conducive to formation and production of frazil-ice, which when deposited on a river bottom, is sometimes referred to as anchor ice. The higher density of frazil-ice, as compared to sheet ice which contains air, causes it to settle in those areas of the river where channel gradient is flat and subsequently results in a solid layer of anchor ice. River flows must then carry over the anchor-ice and in some cases under the layers of cover ice. The reduced channel cross-section produced by the anchor-ice is highly conducive to the damming of cover-ice which during the early spring months, is floated downstream, eventually going aground upon the anchor-ice in the vicinity of the Main Street bridge. This action is repeated until a formidable dam of cover-ice is created. For detailed information concerning ice-jam problems see Exhibit No. 1 - Technical Memorandum on Control of Ice-Jams in Appendix C.

39. SOLUTIONS CONSIDERED

a. General - Consideration has been given to all practicable methods of solving the ice-jam flood problem in the Town of Colebrook. Among the methods considered have been various types of dam construction for formation of an ice-retention reservoir, permeable barriers to hold back damaging ice flows, channel excavation and realignment to increase the depth and velocities of the river, diking of damage areas, annual remedial and preventive measures and combinations of these various methods.

b. Channel Excavation and Realignment - Several alternate plans of channel improvements were investigated. Technical experts of the Cold Regions Research Laboratories report channel improvements by themselves will not eliminate the ice-jam flood problem. They report that retention of frazil ice provides the only positive way of keeping it from adhering to the channel bottom and resulting in a firm layer of anchor ice ultimately reducing flow capabilities of the river and facilitating the build up of cover ice resulting in an ice-jam.

c. Dikes - Protection by means of earth dikes was considered as an alternate solution. Dikes would have to be constructed along both banks of the river for a distance of about one mile. Most of the homes and business establishments which suffer flood damage are, however, located immediately adjacent to the river. Because of the considerable property taking involved, this alternate solution was found impractical and incompatible to local interests.

d. Annual Preventive Measures - Consideration has been given to annual remedial or preventive measures in lieu of protective works of a permanent nature. A method considered involved blasting ice-jams as they occurred, employing explosives such as dynamite. Local interests on several occasions, have employed this procedure but met with only limited success. A common difficulty they report is that the jams form very suddenly and with very little advance notice. Owing to the fact that the greater part of the jam is grounded, considerable explosives and time would be required to blast a free-flowing channel through the ice. In addition, and most important there is generally not sufficient depth of water to carry out successful blasting operations.

e. Debris Barrier Type Structures -

(1) "H"-Piling Barrier. Consideration has been given to driving two rows of "H" piling across the length of the river, each row of piling to be 6 feet apart, but staggered so as to effect an opening of about 3 feet. This type of protection might hold cover ice under some flood conditions dependent upon size of the ice-jam. It would, however, not prevent frazil ice from forming downstream in the quiet areas of the river under the Main Street bridge, which has been the perennial source of trouble in the past.

(2) Timber Ice-Holding Cribs. Consideration was also given to the erection of timber crib rock-filled blocks (8'x8' at the top and 8'x12' at the bottom) each set 14 feet on center in a two-row staggered pattern. This method of protection,considered to be more effective than H-piles in holding the large pieces of sheet ice,would not control frazil ice.

(3) Continuous Timber Crib Weir. Consideration has been given to construction of a continuous low rock-filled timber crib weir. However, in the event of major flood, the entire length of weir would behave as a spillway and, provide no positive way of holding the cover ice in place. This alternative, although more effective than "H"-piles, or

timber crib blocks, would not provide permanent protection and is, therefore, not considered desirable because of the false sense of security which it could create.

f. Ice Retention Dam - A simple overflow dam without gate operation was found to be most effective in controlling ice and preventing jams in Colebrook. A dam with spillway crest about 12 feet above the stream bed would form a pool about one-third of a mile long. The construction of a low concrete spillway and earth dam upstream of Parson Street, would cause cover ice to jam upstream of the built up section of Colebrook. The dam would control the quantity of frazil ice which is now reaching the lower reaches of the river, as little or no frazil ice would pass through the dam. The dam would also retain the ice until it decays in the spring, as well as delay its downstream movement until after the breakup of the ice on the lower reaches of the river. This was found to be the most effective means of solving the problem.

g. Timber Crib versus Concrete Construction - Consideration has been given to the use of a timber crib spillway and abutments in lieu of the concrete spillway and abutments mentioned above. Initially, the cost of timber crib construction is lower, however, assuming the life expectancy of timber as 25 years, higher replacement and maintenance costs result which produce higher annual charges and lower benefit-cost ratios. See Table 12 of this report.

Q. PROPOSED IMPROVEMENTS

40. GENERAL DESCRIPTION

The proposed improvement as outlined herein, has been concurred upon by ice-engineering specialists from the Cold Regions Research and Engineering Laboratories. It is their contention that the construction of a dam upstream of the Main Street bridge will eliminate the major cause of the problem while downstream excavation and channel realignment will afford complete protection. The project provides for the construction of an earth fill dam with a concrete spillway which includes an orifice-type fishway with discharge channel. The structure would be located about 1700 feet upstream of the Parson Street bridge. Channel excavation and realignment of the lower reaches of the Mohwak River beginning about 100 feet downstream of the Main Street bridge, would be included in the improvement. The project also provides the opportunity for utilizing a permanent 14-acre pool as a "project related" recreational potential, which will support a day-use, park-type development including facilities for swimming and picnicking. The recreation area is located about one-quarter mile upstream of the dam along the left bank of the river. A general layout of the recommended plan for ice-jam flood protection in Colebrook is shown on Plate No. 1.

41. HYDRAULIC DESIGN

a. Length of Crest and Maximum Surcharge - The spillway crest elevation will be 1044 feet msl. It was determined that a net crest length of 215 feet with a corresponding surcharge of seven feet for the spillway design flood, would result in the most economical combination of spillway length and surcharge depth. The tailwater for a discharge of 15,000 cfs is estimated to be elevation 1042, or two feet below the crest of the spillway.

b. Freeboard - With maximum surcharge at elevation 1051, the pool will extend about 3000 feet upstream. The relatively short fetch distance would result in a computed significant wave height and wind setup total of less than two feet. A flood producing a head of nine feet (elevation 1053) on the spillway,would raise the tailwater to elevation 1044, thus completely submerging the spillway. Under these conditions,three feet of freeboard between the maximum design water surface and top of the earth embankment is considered adequate.

42. DAM

This feature of work provides for the construction of an earth dam with a top elevation of 1054 feet above msl and a top width of 12 feet. The dam will extend from high ground on the right bank of the Mohawk River to high ground on the left bank of the river for a length of 790 feet, which includes concrete spillway and fishway. The embankment is composed of a compacted random fill core with two feet of rock slope protection on a one-foot gravel bed to elevation 1046 on the upstream slope. A six-inch layer of seeded topsoil from elevation 1046 to the top of the dam concludes treatment of the upstream slope. On the downstream slope a thicker section of rock slope protection rests on a two-foot gravel bed which will be provided to elevation 1046 and a six-inch layer of seeded topsoil from elevation 1046 to the top of the dam. The upstream slope will be 1 vertical on 4 horizontal. The downstream slope will be 1 vertical on 3 horizontal. An impervious fill blanket, 3 feet thick, will be extended 100 feet upstream from the toe of the embankment and 172 feet upstream of the spillway extending across the entire length of the dam and spillway for a length of about 675 feet.

43. SPILLWAY

The concrete spillway will be constructed about 340 feet to the left of the existing stream. This location will permit construction of the dam in the dry and provide economy in design. The spillway weir is 215 feet in length and 18.5 feet in height with an orifice-type fishway at the north abutment. The crest elevation is 1044 feet above msl with a drawdown gate for maintenance purposes at an invert elevation of 1037. A 44-foot long stilling basin section which is formed integral with the spillway will have a 2-foot edge sill on the downstream end and a series of 2-foot by 2-foot rectangular baffle blocks, 2 feet high, positioned 22.5 feet upstream from the end of the stilling basin. The discharge channel downstream of the spillway will be about 400 feet in length,varying in width from 80 feet to 233 feet at the spillway. Four concrete ice breakers with a top elevation of 1049, or 5 feet above the spillway crest,are provided as an integral part of the spillway and are spaced at equal distances between the north and south abutments.

44. ABUTMENT WALLS

The spillway abutment walls are designed as gravity type retaining walls having a maximum height of 28.5 feet and total lengths of 106 feet each. The two walls are identical except that the south abutment has batters on both sides while the north wall forms the side wall for the fishway structure and consequently has a vertical face. The "L"-shaped abutments have legs 31 feet long with embedments of 10 feet into the earth embankments at elevation 1054 msl. On the longer leg of the walls a top elevation of 1054 will be maintained for the first 15 feet. The next 20 feet of this leg will slope from elevation 1054 to 1045 and the last 40 feet will have a level top elevation of 1045 msl. Spillway design necessitates maintaining the wall at this elevation. The walls will have top widths of two feet with one on three batter on the downstream and outside faces and one on six batter on the upstream and inside faces except at the north abutment wall along the fishway. The total base width for the maximum wall section of 28.5 feet high is 16.25 feet.

45. FISHWAY

The orifice-type fishway to be incorporated into the north abutment of the spillway will have an upstream intake one-foot square and invert at elevation 1043 msl and will discharge at elevation 1026.5 msl. Sixteen bays or steps will be required to transport the fish between varying elevations. The bays measure eight feet by 7.5 feet with depths of 10 and 11 feet. Wood baffles six feet high separate adjacent bays of the fishway. The one-foot by one-foot opening in these baffles are stepped up one foot in adjacent bays. These and other construction features of the fish ladder are more clearly shown on Plate No. 5 of this report. The structure has been designed in accordance with the standards of the State of New Hampshire Fish and Game Department.

46. TIMBER ICE HOLDING CRIBS

Five ice-holding timber cribs are provided 150 feet upstream of the spillway. The cribs are eight-feet square at the top and 14 feet long by 8 feet wide at the bottom, they are about 12 feet above the original ground and are filled with rock. The upstream face has a slope of 2 vertical on 1 horizontal and has 5"x5"x½" angle irons at each corner. Details of the timber crib are shown on Plate No. 5, location is noted on Plate No. 2.

47. DOWNSTREAM CHANNEL IMPROVEMENTS

Channel improvements downstream of the Main Street bridge will include 2000 l.f. of channel excavation in the reach between the Main Street bridge and the Maine Central Railroad bridge. The elevation of the existing channel bottom at these bridges is 1012 feet msl and 1002 feet, msl, respectively. The channel slope in this reach varies considerably because of material deposited at various locations. A pilot channel will be excavated 20 feet wide from station 1+00 to station 14+00 with side slopes of 1 on 2. It is not anticipated that silting conditions during construction will become serious enough to adversely effect fish population, however, should conditions so necessitate, we will provide silt barriers in accordance with desires of the fish and wildlife interests.

Diversion of the Mohawk River in the vicinity of the Connecticut River confluence for a distance of 600 feet will supplement the above-mentioned improved channel slope and in so doing increase the passage of flows from the Mohawk River, past Colebrook, into the Connecticut River. The existing channel bottom at the head of the proposed diversion has an elevation of 1001 msl. The Connecticut River has a bed elevation of about 998 msl. The existing stream in this general area meanders for a distance of 1200 feet from the start of the improvement to the Connecticut River. The slope of the improved channel diversion will be about twice as steep as the existing slope. Channel improvement is shown on Plate Nos. 6 and 7.

48. RELOCATION OF UTILITIES

The plan of improvement will not require the relocation of utilities. There are no changes contemplated for existing sewer, water or other drainage lines.

R. MULTIPLE-PURPOSE FEATURES

49. GENERAL

The plan provides for the control of ice-jam flooding. The dam will have only limited flood control storage in the event of a major flood. Project improvements, however, provide opportunities for a "Project-Related" recreation potential and the incorporation of an orifice-type fishway to mitigate losses which might otherwise occur by reason of dam construction.

50. FISHWAY

A project feature provides for the incorporation of an orifice-type fishway abutting the north abutment adjacent to the spillway. The type and design of the fishway has been reviewed by the U. S. Department of Interior, Fish and Wildlife Service, and the New Hampshire Fish and Game Department. Attention is invited to Exhibit Nos. 2-3 of Appendix A.

51. RECREATION

Minimum basic recreational facilities to make possible public use of "project-related" recreation potential have been included in the project plan. These improvements have been limited to those specific facilities and lands appropriate to the site and clearly required to meet those needs, which can be met more economically at the project than at any other site in the general area.

In accordance with policies outlined in ER 1165-2-4, which encourage non-Federal entities to assume responsibility for developing recreational facilities at Corps non-reservoir projects, local interests would be required to furnish those items of cooperation outlined in Paragraph AA.

S. RECREATIONAL DEVELOPMENT

52. RESERVOIR RECREATION AREA

a. Location. - The recreation area will be located one quarter mile upstream of the Mohawk River Dam on a 14-acre permanent pool provided by the project for control of ice-jams. The site will be situated in the Town of Colebrook, three miles easterly of the Vermont border and eight miles southerly of the Canadian border.

b. Existing Scenic Qualities. - The project will be situated in a highly scenic valley of the White Mountain area of northern New Hampshire. The valley is deep and winding with mountain peaks in the vicinity ranging from 2200 to 3800 feet in elevation. In the distance can be seen Mount Washington (elevation 6288 feet msl), the highest mountain in New England. The steep walled valley with a mixture of maples, oaks, and pines has highly scenic qualities, especially in the fall foliage season.

c. General Project Characteristics. - The project will provide a 14-acre permanent pool with crystal clear mountain water. The shoreline in the proposed development area is suited to economical development and has ample area for optimum development. The permanent pool will add to the scenic qualities of the area.

d. Type of Recreation For Which the Project is Suited. - The project is well suited for a day-use, park-type development including facilities for swimming and picnicking.

e. Region Served. - The 1960 population figures show about 14,600 people residing within 25 miles of the project, an increase of 3.4 percent since 1950. The reservoir area is easily accessible by north-south U. S. Route 3 and east-west by New Hampshire Route 26. Tourism in this area of the state is high. The 25-mile zone of influence covers portions of Vermont, Maine, New Hampshire and the Province of Quebec, Canada.

f. Plan of Improvement. - The proposed development will include provisions for access, parking, picnicking and swimming with change house and toilet facilities. The development plan takes into consideration the limitation of the existing land and is estimated to be adequate to meet the existing needs. The development has a design load of 350 people and was planned for an annual attendance of 13,000 visitors. The development area could be expanded to accommodate a design load of 500 people to meet any future needs. Additional expansion beyond that point would be overcrowded.

(1) Cost of Improvement - The estimated cost for construction of the recreational facilities are shown in Table 7.

TABLE 7
RECREATION DEVELOPMENT COST

Item No	Description	Quantity	Unit	Unit Price	Estimated Amount
1	Access Road	1500	l.f.	$12.00	$ 18,000
2	Parking Area	2600	s.y.	1.10	2,860
3	Selective Clearing	5	acres	300.00	1,500
4	Drainage-Includes filling;grading to drain; and top-soiling low wet areas	8000	s.y.	.55	4,400
5	Beach Development	4000	s.y.	l.s.	2,630
6A	Change House	1	each	1500.00	1,500
6B	Pit Toilet	1	each	2000.00	2,000
7	Picnic Tables	24	each	85.00	2,040
8	Fireplaces	12	each	60.00	720
					$ 35,650
		Contingencies			5,350
		TOTAL			$ 41,000

(2) Annual Operation and Maintenance Costs - Annual operation cost is estimated at $1500 which provides for one full-time summer employee to manage and maintain the area. Another $500 is allocated to upkeep and replace facilities and the servicing of the chemical toilet. Total cost is $2,000.

(3) Annual Visitors - Using an annual visitor day benefit of $0.75 the annual benefits for 13,000 visitors is $9,800.

(4) Additional details and supporting data concerning existing recreational opportunities within the area and alternative considerations are given in Appendix F.

T. REAL ESTATE REQUIREMENTS

The acquisition of land for the Colebrook ice-jam control dam and channel improvements will be the responsibility of local interests; namely, the Town of Colebrook. Field reconnaissance and conferences with local officials were used as a basis for estimates of real estate costs. The general project area consists of woodland, pasture land and some tillable lands. The area is rural in character. There are no highway or cemetary relocations involved in the project, also no pipelines or electrical transmission lines within the reservoir area. The total area to be acquired consists of 34 acres of permanent land taking and 27 acres of temporary easements, as follows:

Permanent Acres	Classification	Estimated Value
21.2	Reservoir Pool	$ 6,500
3.7	Dam and Discharge Channel	1,300
2.2	Recreational Area	850
2.3	Access Road	850
4.6	Downstream Channel Improvements	1,500
34.0		$ 11,000

Temporary Acres	Classification	Estimated Value
2.0	Borrow Area	$ 1,000
19.8	Flowage at Elevation 1055	2,200
2.4	Spoil Area	270
4.8	Downstream of Main Street	530
27.0		$ 4,000(1)
	Contingencies & Acquisition Costs	3,000
	TOTAL	$ 18,000

(1) Represents administrative cost only in the obtainment of construction permits, etc.

U. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

53. GENERAL

Estimates of Federal and non-Federal first costs and annual charges are given in Table 8. These estimates have been prepared on the basis that local interests would bear the cost of relocations, and alterations to utilities; furnish all lands, water rights and rights-of-way necessary for project construction; and to operate and maintain the project after completion. Unit prices used in estimating costs are based on average bid prices for similar work in the same general area. The prices are based on 1964 price level and include minor items of work which are not separately detailed in the cost estimates. Also included as Table 13 are the estimated Federal and non-Federal first costs and annual charges utilizing timber design and construction for spillway and abutments.

54. BASIS OF COST ESTIMATES

Detailed cost estimates have been made upon the basis of a design which would provide an economical and safe structure for the site. Estimates of quantities have been made upon the basis of neat outlines of the proposed designs and foundation requirements. Costs were computed as outlined in the Corps of Engineers Engineering Manual 1120-2-104.

55. CONTINGENCIES, ENGINEERING, SUPERVISION, AND ADMINISTRATION

To cover contingencies, estimates of construction costs have been increased by 15 percent. The cost of future engineering and design has been taken as 7 percent of the construction costs. The costs of supervision and administration has been taken as nine percent of the combined construction and engineering costs.

56. BASIS OF ANNUAL CHARGES

The estimates of annual charges were based on the use of public funds for the total investment over a period of 50 years. Federal and non-Federal annual charges include 3-1/8 percent of the total investment for interest and 0.854 percent for amortization. Maintenance charges were based on the particular site conditions and previous experience with similar projects.

TABLE NO. 8

Detailed Cost Estimate

Colebrook Ice-Retention Dam and Reservoir

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Lands & Damages	1	Job	L.S.	$ 18,000	$ 18,000
Reservoir					
Clearing	1	Job	L.S.	3,000	
Contingencies				400	
					3,400
Dam (Flood Control & Recreation)					
Site Preparation	1	Job	L.S.	5,000	
Stream Control	1	Job	L.S.	5,600	
Excavation					
Stripping	17,700	C.Y.	.60	10,620	
Suitable for Random Fill	24,600	C.Y.	.90	22,140	
Downstream from Main Street	10,500	C.Y.	.80	8,400	
Compacted Random Fill	8,300	C.Y.	.75	6,225	
Compacted Impervious Fill	23,000	C.Y.	1.50	34,500	
Compacted Impervious Backfill	800	C.Y.	5.00	4,000	
Rock Slope Protection	4,300	C.Y.	4.50	19,350	
Rock Channel Protection	1,000	C.Y.	5.00	5,000	
Gravel Bedding	2,600	C.Y.	2.50	6,500	
Road Gravel, Treated	200	C.Y.	3.00	600	
Concrete Spillway	4,500	C.Y.	45.00	202,500	
Concrete Abutments	1,550	C.Y.	46.00	71,300	
Concrete Fishway	200	C.Y.	60.00	12,000	
Concrete Fill	300	C.Y.	40.00	12,000	
Filter Stone	700	C.Y.	10.00	7,000	
Filter Sand	500	C.Y.	8.00	4,000	
Topsoil, Seeded	3,100	S.Y.	1.00	3,100	
Timber Fishway Baffles	2	MFBM	125.00	250	
Timber Holding Cribs (5)	1	Job	L.S.	5,600	
Fishway Gate and Guides	1	Job	L.S.	1,000	
Draw Down Gate	1	Job	L.S.	1,000	
Miscellaneous	1	Job	L.S.	1,000	
				$448,685	
Contingencies				67,215	
					515,900

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TABLE NO. 8 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Recreation					
Recreation Facilities	1	Job	L.S.	$ 35,650	
Contingencies				5,350	
					$ 41,000
Access Road					
Road	1	Job	L.S.	10,000	
Contingencies				1,700	
					11,700
			TOTAL DIRECT COSTS		$590,000
Indirect Costs					
Engineering and Design					$ 47,000(1)
Supervision and Administration					54,000
			TOTAL INDIRECT COSTS		$101,000(1)
		TOTAL PROJECT FIRST COST			$691,000

(1) Does not include $46,000 for prior and present reports.

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TABLE NO. 9

COLEBROOK DAM AND RESERVOIR

COST ALLOCATION STUDIES

	Multiple Purpose Project				Alternative Single Purpose Projects	
	Specific Costs					
	Flood Control	Recreation	Joint Use Costs	Total Costs	Flood Control	Recreation
Permanent Features						
Lands and Damages		$ 2,000	$ 16,000	$ 18,000	$ 16,000	$ 1,000
Relocations				0	0	0
Reservoir Clearing			3,500	3,500	3,500	0
Dam						
Main Dam			608,300	608,300	606,000	126,500
Outlet			1,900	1,900	1,900	13,700
Roads			11,600	11,600	11,600	48,400
Recreation Facilities		47,700		47,700		34,400
TOTAL PROJECT FIRST COSTS	0	49,700	641,300	691,000	639,000	224,000
Investment and Annual Charges						
Construction expenditures	0	49,700	641,300	691,000	639,000	224,000
Interest during construction	0	0	0	0	0	0
Investment	0	49,700	641,300	691,000	639,000	224,000
Annual Charges						
Interest	0	1,600	20,000	21,600	20,000	7,000
Amortization	0	400	5,500	5,900	5,500	1,900
Operation and Maintenance	0	1,600	800	2,400	800	2,400
Major Replacements	0	400	0	400	0	400
TOTAL ANNUAL CHARGES	0	4,000	26,300	30,300	26,300	11,700

TABLE NO. 10

COLEBROOK DAM & RESERVOIR
COST ALLOCATION STUDIES
ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

		Flood Control	Recreation	Total
1.	ALLOCATION OF ANNUAL COSTS			
a.	Benefits	$ 22,900	$ 9,800	$ 32,700
b.	Alternate cost	26,300	11,700	38,000
c.	Benefits limited by alternate cost	22,900	9,800	32,700
d.	Separable cost	18,600	4,000	22,600
e.	Remaining benefits	4,300	5,800	10,100
f.	Allocated joint cost	3,300	4,400	7,700
g.	Total allocation, project cost	21,900	8,400	30,300
2.	ALLOCATION OF OPERATION & MAINTENANCE COSTS			
a.	Separable cost	0	1,600	1,600
b.	Allocated joint cost	300	500	800
c.	Total allocation, O&M	300	2,100	2,400
d.	Specific costs	0	1,600	1,600
e.	Allocated joint use costs	300	500	800
f.	Ratio for allocation of joint use O&M	37.5%	62.5%	100%
3.	ALLOCATION OF MAJOR REPLACEMENTS			
a.	Separable cost	0	400	400
b.	Allocated joint cost	0	0	0
c.	Total allocation, major replacements	0	400	400
4.	ALLOCATION OF INVESTMENT			
a.	Annual investment cost	21,600	5,900	27,500
b.	Ratio of annual investment	78.5%	21.5%	100%
c.	Allocated investment	542,400	148,600	691,000
5.	ALLOCATION OF CONSTRUCTION EXPENDITURES			
a.	Specific investment	0	49,700	49,700
b.	Investment in joint use facilities	542,400	98,900	641,300
c.	Interest during construction on J.U.F.	0	0	0
d.	Construction expenditures on J.U.F.	542,400	98,900	641,300
e.	Percent of construction expend. on J.U.F.	84.6%	15.4%	100%
f.	Construction expend. on specific facil.	0	49,700	49,700
g.	Total construction expenditures	542,400	148,600	691,000
SUMMARY				
	Total construction expenditures	542,400	148,600	691,000
	Annual costs	21,900	8,400	30,300
	Annual benefits	22,900	9,800	32,700
	Benefit/cost ratio	1.05	1.17	1.08

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TABLE NO. 11

COLEBROOK DAM & RESERVOIR
SUMMARY OF COST APPORTIONMENT

	Flood Control	Recreation
Specific First Cost	$ 0	$ 49,700
Allocated Joint Use First Cost	542,400	98,900
% of Allocated Joint Use First Cost	84.6%	15.4%
Annual Investment Cost	$ 21,600	$ 5,900
% of Annual Investment Cost	78.5%	21.5%
Specific O.M. & R. Cost	$ 0	$ 2,000
Allocated Joint Use, O.M. & R.	300	500
% of Allocated Joint Use, O.M. & R.	37.5%	62.5%

TABLE NO. 12

COLEBROOK DAM & RESERVOIR
SUMMARY OF COSTS, ANNUAL CHARGES AND BENEFITS

First Costs			
Federal			
	Flood Control	$ 526,400	
	Recreation	122,600	
	Total		$ 649,000
Non-Federal			
	1/2 Separable Recreation Cost	$ 26,000	
	Project Lands and Damages	16,000	
	Total		42,000
TOTAL PROJECT FIRST COSTS			$ 691,000
Annual Charges			
Federal			
	Flood Control		
	526,400 x 3.125%	$ 16,450	
	526,400 x .00854	4,550	
	Recreation	3,900	
	Total		$ 24,900
Non-Federal			
	1/2 Separable Recreation Cost	$ 2,000	
	Project Lands	600	
	Operation, Maintenance & Replace.	2,800	
	Total		5,400
TOTAL ANNUAL CHARGES			$ 30,300
Annual Benefits			$ 32,700
Benefit - Cost Ratio			1.08

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TABLE NO. 13

Colebrook Dam and Reservoir

Estimate of First Costs and Annual Charges

Timber Crib and Earth Fill Dam

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Lands & Damages	1	Job	L.S.	$ 18,000	$ 18,000
Reservoir					
Clearing	1	Job	L.S.	3,000	
Contingincies				400	
					3,400
Dam (Flood Control & Recreation)					
Site Preparation	1	Job	L.S.	$ 5,000	
Clearing Reservoir	1	Job	L.S.	3,000	
Stream Control	1	Job	L.S.	5,600	
Excavation					
Stripping	13,600	C.Y.	.60	8,160	
Suitable for Random	15,200	C.Y.	.90	13,680	
Downstream from Main Street	10,500	C.Y.	.80	8,400	
Compacted Random	10,000	C.Y.	.75	7,500	
Compacted Impervious Fill	34,100	C.Y.	1.50	51,150	
Compacted Impervious Backfill	400	C.Y.	5.00	2,000	
Rock Slope Protection	5,900	C.Y.	4.50	26,550	
Rock Channel Protection	500	C.Y.	5.00	2,500	
Gravel Bedding	3,400	C.Y.	2.50	8,500	
Road Gravel, Treated	200	C.Y.	3.00	600	
Timber Cribbing	376	MFBM	340.00	127,840	
Treated Planking	38	MFBM	300.00	11,400	
Untreated Planking	14	MFBM	275.00	3,850	
Rock Fill and Rock Spalls	8,800	C.Y.	4.50	39,600	
Topsoil, Seeded	6,300	S.Y.	1.00	6,300	
Timber Ice-Holding Cribs	1	Job	L.S.	5,600	
Miscellaneous	1	Job	L.S.	2,000	
Fishway Gate and Guides	1	Job	L.S.	1,000	
Chain Link Fence	1	Job	L.S.	1,200	
				$341,430	
Contingencies				51,170	
					$392,600

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TABLE NO. 13 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Recreation					
Recreation Facilities	1	Job	L.S.	$ 35,650	
Contingencies				5,350	
					$ 41,000
Access Road					
Road	1	Job	L.S.	10,000	
Contingencies				2,000	
					$ 12,000
		TOTAL DIRECT COSTS			$467,000
Indirect Costs					
Engineering and Design					$ 37,000 (1)
Supervision and Administration					42,000
		TOTAL INDIRECT COSTS			$ 79,000
		TOTAL PROJECT FIRST COST			$546,000

(1) Does not include $46,000 for prior and present reports.

ANNUAL CHARGES
50 year life

FEDERAL		
Interest (.03125 x 504,000)	$15,700	
Amortization (.00854 x 504,000)	4,300	
Total Federal Annual Charges		$20,000
NON-FEDERAL		
Interest (.03125 x 42,000)	$ 1,300	
Amortization (.00854 x 42,000)	400	
Maintenance	1,000	
Maintenance Recreational Facilities	2,000	
Major Replacements (2)	8,000	
Total Non-Federal Annual Charges		$12,700
Total Annual Charges		$32,700

(2) Complete replacement of timber section in 25 years.

V. ESTIMATES OF BENEFITS

Average annual ice-jam flood damage prevention benefits, taken as the difference between average annual losses under existing conditions and those losses remaining after construction, amount to \$18,200. The project will also yield redevelopment benefits of \$4,700 annually and recreation benefits of \$9,800 annually. Total annual benefits attributable to the project amount to \$32,700. It is not anticipated that the project will result in any increased utilization or enhancement benefits. Details of the derivations of benefits are set forth in Appendix B.

W. COMPARISON OF BENEFITS AND COSTS

Total average annual benefits for the Colebrook Local Protection Project are estimated at \$32,700 and total average annual costs utilizing a concrete spillway are estimated at \$30,300. The resulting ratio of benefits to cost is 1.1 to 1.0.

X. COST ALLOCATION

Allocation of cost to the purposes of flood control and recreation were made by the separable cost-remaining benefit method. Details of the cost allocation are presented in Tables 9 and 10.

Y. PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

The Division Engineer finds that past ice-jam floods have caused substantial damages to the lands and existing structures along the Mohawk River in Colebrook and that frequency of such ice-jam flooding is increasing to a current rate of once every two years. He concludes that a plan of improvement consisting of an earth fill dam and concrete spillway with an orifice-type fishway, as well as the widening and deepening of the Mohawk River at critical locations, would provide the maximum practicable degree of protection for the town against future ice-jam flooding. The project further provides the opportunity for utilizing the permanent 14-acre pool as a "project-related" recreational potential. A day-use, park-type recreation development including facilities for swimming and picnicking have been included in project analysis. Project formulation resolved itself into one plan of protection which afforded economic justification, construction feasibility, and compatibility with existing improvements in the area. Protection can be provided most suitably by the plan as submitted herein for approval.

Total project costs of the recommended plan are estimated at \$691,000 exclusive of preauthorization costs of \$46,000, of which \$649,000 represents the Federal share and \$42,000 the non-Federal share. The plan of protection will yield average annual benefits of \$32,700 as against annual costs of \$30,300, producing a benefit cost ratio of 1.1 to 1.0.

Z. SCHEDULES FOR DESIGN AND CONSTRUCTION

57. DESIGN

It is estimated that preparation of contract plans and specifications for the project, at an estimated cost of $43,000, can be completed in six months after approval of this report.

58. CONSTRUCTION

Construction of the project can be accomplished under a single contract to be completed in less than 2 years. Funds for the construction of the project would be requested upon evaluation of bids received.

AA. OPERATION AND MAINTENANCE

Maintenance of this project will be the responsibility of local interests. Periodic inspections will be made to assure that adequate maintenance is performed in accordance with regulations prescribed by the Secretary of the Army. It is estimated that maintenance of the project will cost local interests $800 annually and $2,000 annually for the recreation facilities. An operation and maintenance manual will be furnished to the Town of Colebrook upon completion of the project.

BB. LOCAL COOPERATION

In accordance with Section 205 of Public Law 87-874, referred to as the 1962 Flood Control Act, local interests would be required to provide without cost to the United States the following:

(1). Provide without cost to the United States all lands, easements, rights-of-way, utility relocations and alterations, and highway or highway bridge construction and alterations necessary for project construction.

(2). Hold and save the United States free from damages due to the construction works and adjust all claims concerning water rights.

(3). Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.

(4). Assume full responsibility for all project costs in excess of the Federal cost limitation of $1 million.

(5). Prevent future encroachment which might interfere with proper functioning of the project for flood control.

In accordance with policies outlined in ER 1165-2-4 non-Federal entities must assume responsibility for developing recreational facilities at Corps non-reservoir projects. In this connection, local interests will be required to furnish the following:

(a) Provide all additional lands, or rights in land, required to insure public control of the development;

(b) Where the appraised value of the land provided under (a) above amounts to less than 50 percent of the recreational development, make additional contributions sufficient to bring the non-Federal share to at least that level; which additional contribution may consist of the actual cost of carrying out an agreed-upon portion of the development, or a cash contribution, or a combination of both;

(c) Operate and maintain for the life of the Federal project the recreational area and all facilities installed pursuant to the agreement;

(d) Assume access to all on equal terms.

CC. COORDINATION WITH OTHER AGENCIES

Plans for local protective works in Colebrook have been reviewed by officials of the Town of Colebrook and the State of New Hampshire. Statements have been received from the U.S.Department of the Interior, Fish and Wildlife Service, and the Bureau of Outdoor Recreation regarding the fishery resource, and the recreational features as they pertain to projects. Their comments are listed as Exhibit Nos. 2, 3 and 4 of Appendix A. The project has no effect on hydro-electric power generation, water supply, pollution abatement, or other collateral water resource uses.

DD. CONCLUSIONS

There are a number of measures which can be taken to alleviate the ice-jam situation slightly, and other, more expensive measures which will prevent the jams effectively. As indicated in Appendix C in report prepared by CRREL, it is important that we control the downstream movement of frazil ice which, when deposited upon the channel bottom, becomes anchor ice and at the same time seriously affects the flow capabilities of the stream to transport sections of cover ice which go aground. Repetition of this action results in creation of a sizeable jam. The introduction of a premature runoff occasioned by higher temperature, heavy rains and melting snow sets the stage for the flood problem. Investigations and studies for the local protection project covered by this report lead to the following conclusions:

(a) The Town of Colebrook faces a continual threat of damages from future ice-jam flooding.

(b) The desires of local interests are for the elimination of damaging ice-jams which threaten security of residential and business establishments that border the river.

(c) The project further provides the opportunity for utilizing a permanent 14-acre pool as a "project-related" recreational potential.

(d) Protection can be provided most suitably by the proposed plan at a total estimated Federal cost of $649,000 and local cost of $42,000.

(e) The project is economically justified by the ratio of total annual benefits to actual annual costs of 1.1 to 1.0. It should be noted that the project has been amortized over a 50-year life which is the general practice for improvements constructed under the 205 program. The project, however, has been designed in accordance with review comments and practices for general dam construction and its life expectancy is closer to 100 years. Had a hundred-year life been analyzed, the benefit-cost ratio would raise to 1.3 to 1.0.

(f) The threat of recurring damaging floods makes it desirable to construct the project as soon as possible.

EE. RECOMMENDATIONS

It is recommended that the project, as submitted in this report, be authorized by the Chief of Engineers under the provisions of the Flood Control Act of 1948, as amended, and that additional funds be allotted in the amount of $ 47,000 for the preparation of plans and specifications. Funds for construction will be requested upon receipt and analysis of bids for construction.

CORPS OF ENGINEERS

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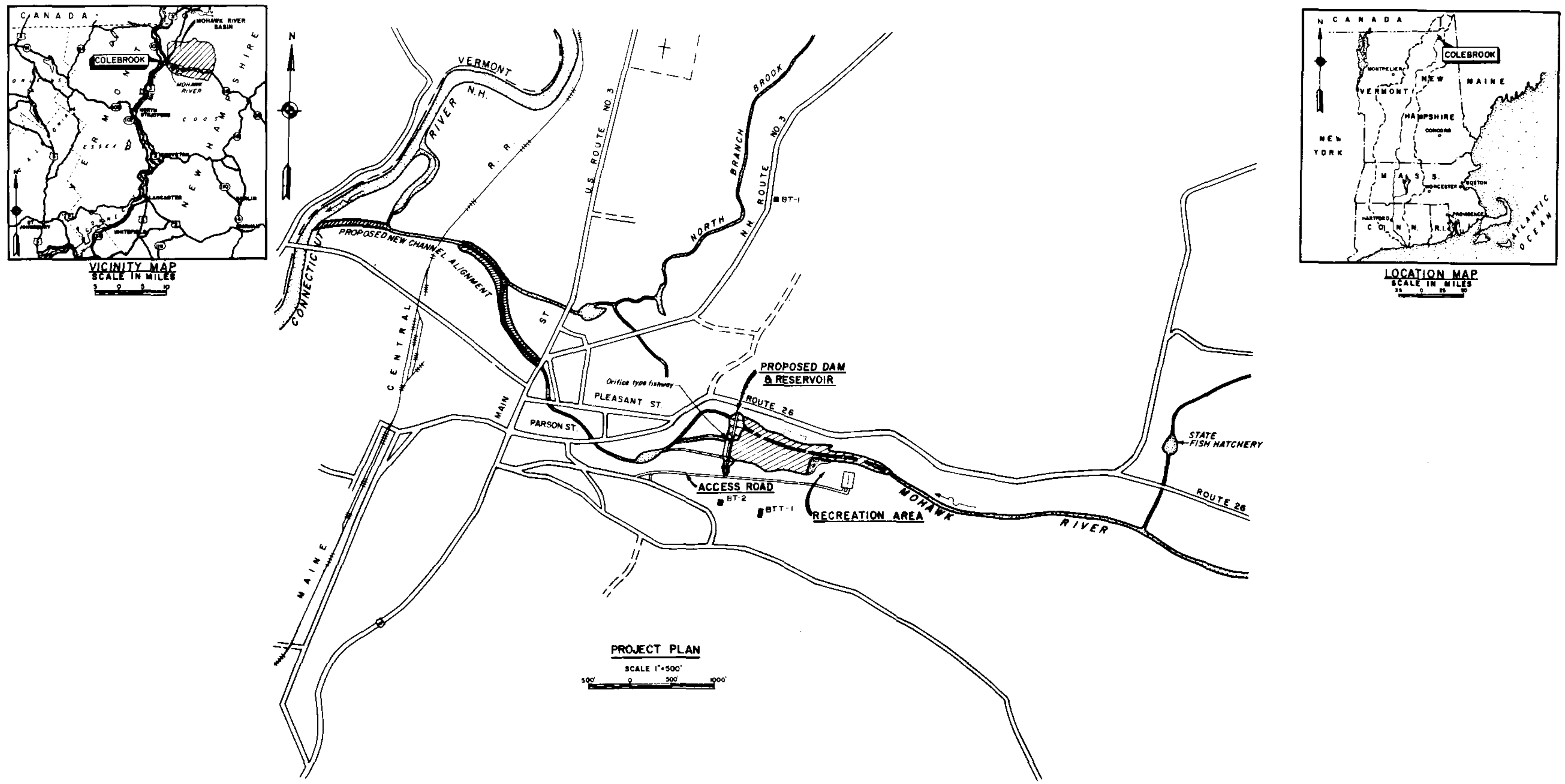


NOTES:
■ Denotes approximate location of borrow explorations.
For graphic logs of these explorations, see Plate No. D-1

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DR. BY F.W.G. | TR. BY G.H.D. | CK. BY

SUBMITTED

CHIEF, SECTION

REVIEWED

PROJECT ENGINEER

APPROVED

CHIEF, DESIGN BRANCH

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION

PROJECT PLAN

MOHAWK RIVER NEW HAMPSHIRE

APPROVED: DATE MARCH 1964

CHIEF ENGINEERING DIV.

SCALE AS SHOWN | SPEC. NO. CIV. ENG-19-016-

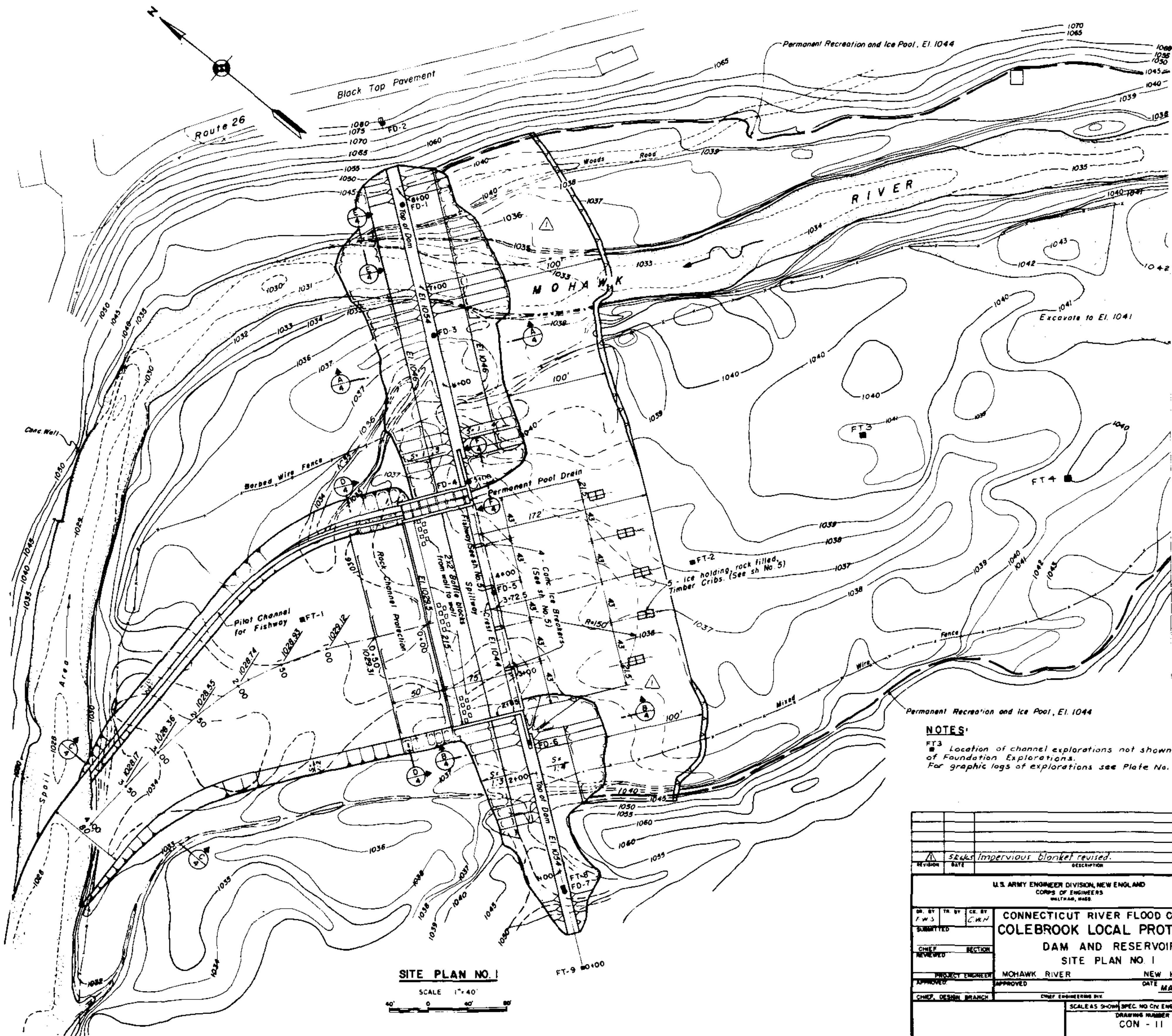
DRAWING NUMBER
CON - 11

SHEET

PLATE NO-1

CORPS OF ENGINEERS

U. S. ARMY



NOTES:

FT3 ■ Location of channel explorations not shown on plan of Foundation Explorations.
For graphic logs of explorations see Plate No. D-1

REVISION	DATE	DESCRIPTION
△	5-6-65	Impervious blanket revised.

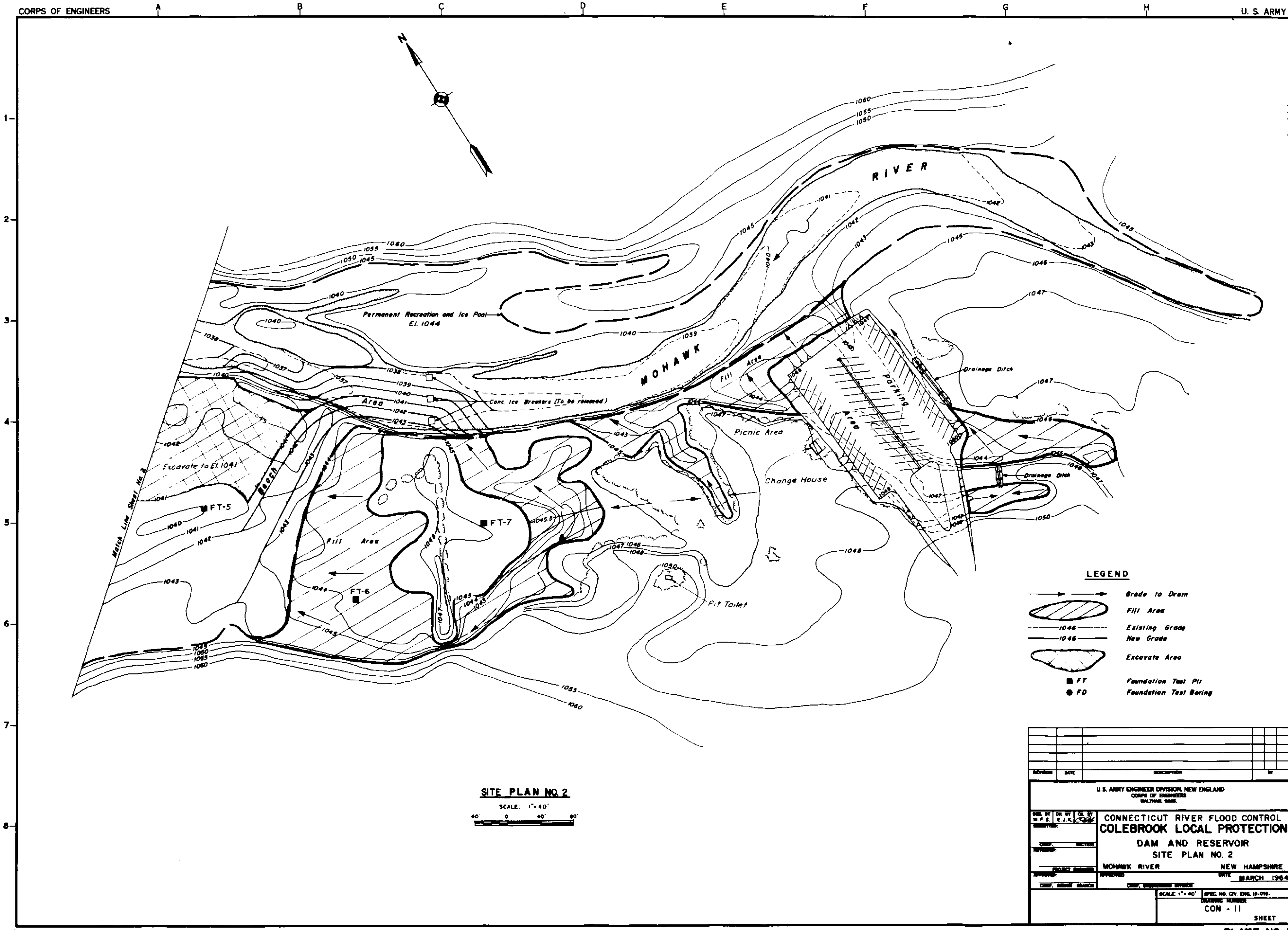
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY F.W.S. | TR. BY | CK. BY C.W.H.

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
DAM AND RESERVOIR
SITE PLAN NO. 1
MOHAWK RIVER — NEW HAMPSHIRE

SUBMITTED — CHIEF SECTION
REVIEWED — PROJECT ENGINEER
APPROVED — CHIEF, DESIGN BRANCH
APPROVED — CHIEF ENGINEERING DIV.
DATE MARCH 1964
SCALE AS SHOWN | SPEC. NO. CIV. ENG.-19-016-
DRAWING NUMBER CON - 11
SHEET

PLATE NO-2


CORPS OF ENGINEERS
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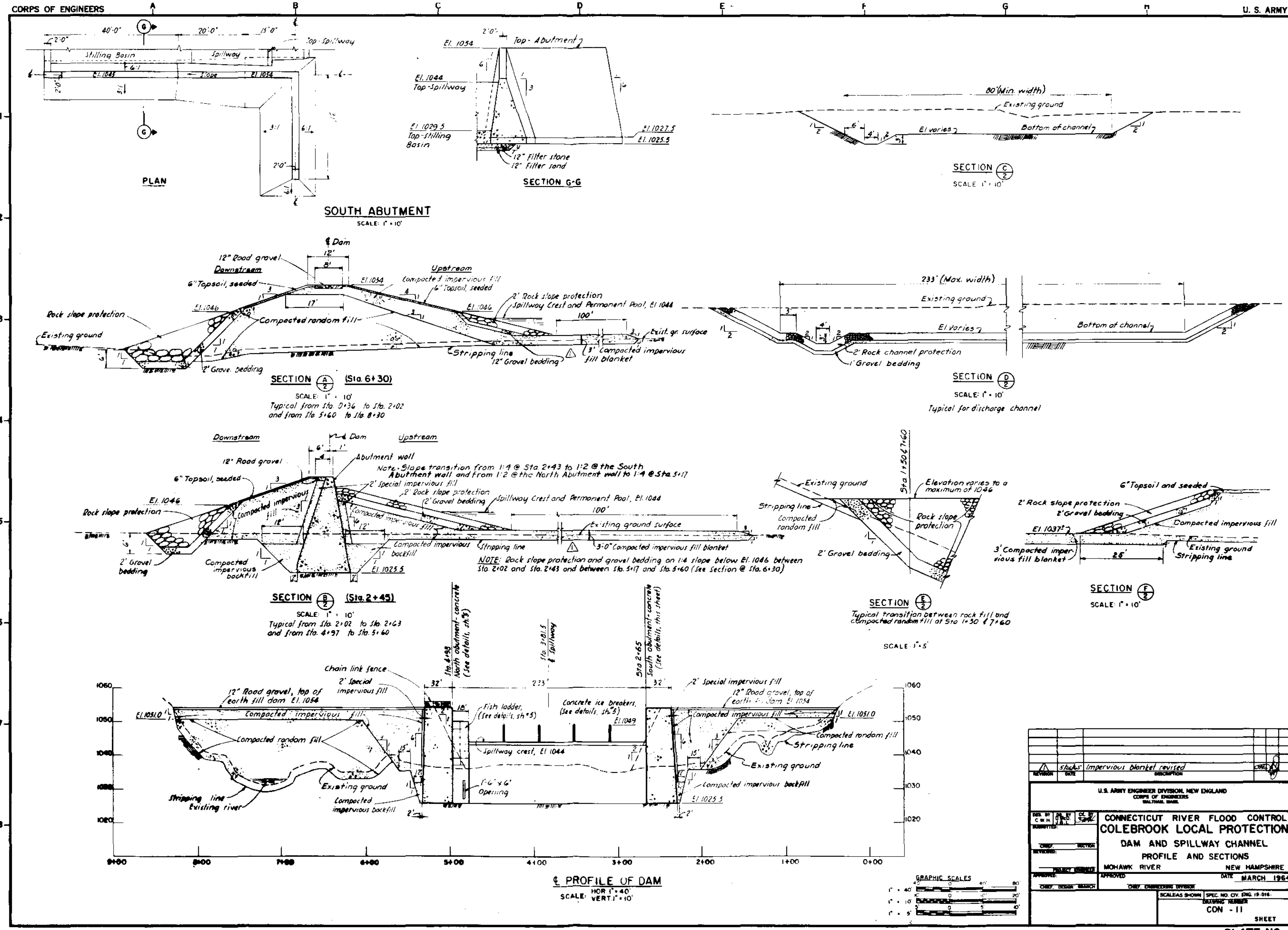
N
RIVER
MOHAWK
Permanent Recreation and Ice Pool
El. 1044
Conc Ice Breakers (To be removed)
Fill Area
Parking Area
Drainage Ditch
Picnic Area
Change House
Pit Toilet
Excavate to El. 1041
Beach Area
Match Line Sheet No. 2
FT-5
FT-6
FT-7
LEGEND
Grade to Drain
Fill Area
Existing Grade
New Grade
Excavate Area
FT Foundation Test Pit
FD Foundation Test Boring
SITE PLAN NO. 2
SCALE: 1" = 40'
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
W.F.S.
E.J.K.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
DAM AND RESERVOIR
SITE PLAN NO. 2
MOHAWK RIVER
NEW HAMPSHIRE
MARCH 1964
SCALE: 1" = 40'
CON - 11
SHEET

PLATE NO-3



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PLAN
SECTION G-G
SOUTH ABUTMENT
SCALE: 1" = 10'
Top-Abutment
El. 1054
El. 1044
Top-Spillway
El. 1029.5
Top-Stilling Basin
El. 1027.5
El. 1025.5
12" Filter stone
12" Filter sand
Stilling Basin
Spillway
80' (Min. width)
Existing ground
El varies
Bottom of channel
SECTION C/2
SCALE 1" = 10'
¢ Dam
12" Road gravel
Downstream
Upstream
6" Topsoil, seeded
Compacted impervious fill
2' Rock slope protection
Spillway Crest and Permanent Pool, El. 1044
Rock slope protection
Existing ground
Compacted random fill
Stripping line
12" Gravel bedding
3' Compacted impervious fill blanket
Exist. gr. surface
2' Gravel bedding
SECTION A/2 (Sta. 6+30)
SCALE: 1" = 10'
Typical from Sta. 0+36 to Sta. 2+02 and from Sta. 5+60 to Sta. 8+30
233' (Max. width)
2' Rock channel protection
1' Gravel bedding
SECTION D/2
SCALE: 1" = 10'
Typical for discharge channel
Abutment wall
Note - Slope transition from 1:4 @ Sta. 2+43 to 1:2 @ the South Abutment wall and from 1:2 @ the North Abutment wall to 1:4 @ Sta. 5+17
2' Special impervious fill
2' Gravel bedding
Existing ground surface
3'-0" Compacted impervious fill blanket
Compacted impervious backfill
El. 1046
El. 1025.5
NOTE: Rock slope protection and gravel bedding on 1:4 slope below El. 1046 between Sta. 2+02 and Sta. 2+43 and between Sta. 5+17 and Sta. 5+60 (See Section @ Sta. 6+30)
SECTION B/2 (Sta. 2+45)
SCALE: 1" = 10'
Typical from Sta. 2+02 to Sta. 2+63 and from Sta. 4+97 to Sta. 5+60
Sta. 1+50 & 7+60
Elevation varies to a maximum of 1046
Rock slope protection
SECTION E/2
Typical transition between rock fill and compacted random fill at Sta. 1+50 & 7+60
SCALE 1" = 5'
6" Topsoil and seeded
2' Rock slope protection
2' Gravel bedding
Compacted impervious fill
El. 1037.0
3' Compacted impervious fill blanket
Existing ground
Stripping line
SECTION F/2
SCALE: 1" = 10'
Sta. 4+98 North abutment - concrete (See details, sh. 5)
Sta. 3+81.5 ¢ Spillway
Sta. 2+65 South abutment - concrete (see details, this sheet)
Chain link fence
12" Road gravel, top of earth fill dam El. 1054
Compacted impervious fill
Fish ladder (See details, sh. 5)
Concrete ice breakers (See details, sh. 5)
El. 1049
Spillway crest, El. 1044
1'-6" x 6' Opening
Existing river
El. 1051.0
¢ PROFILE OF DAM
SCALE: HOR 1" = 40' VERT 1" = 10'
GRAPHIC SCALES
shoulder impervious blanket revised
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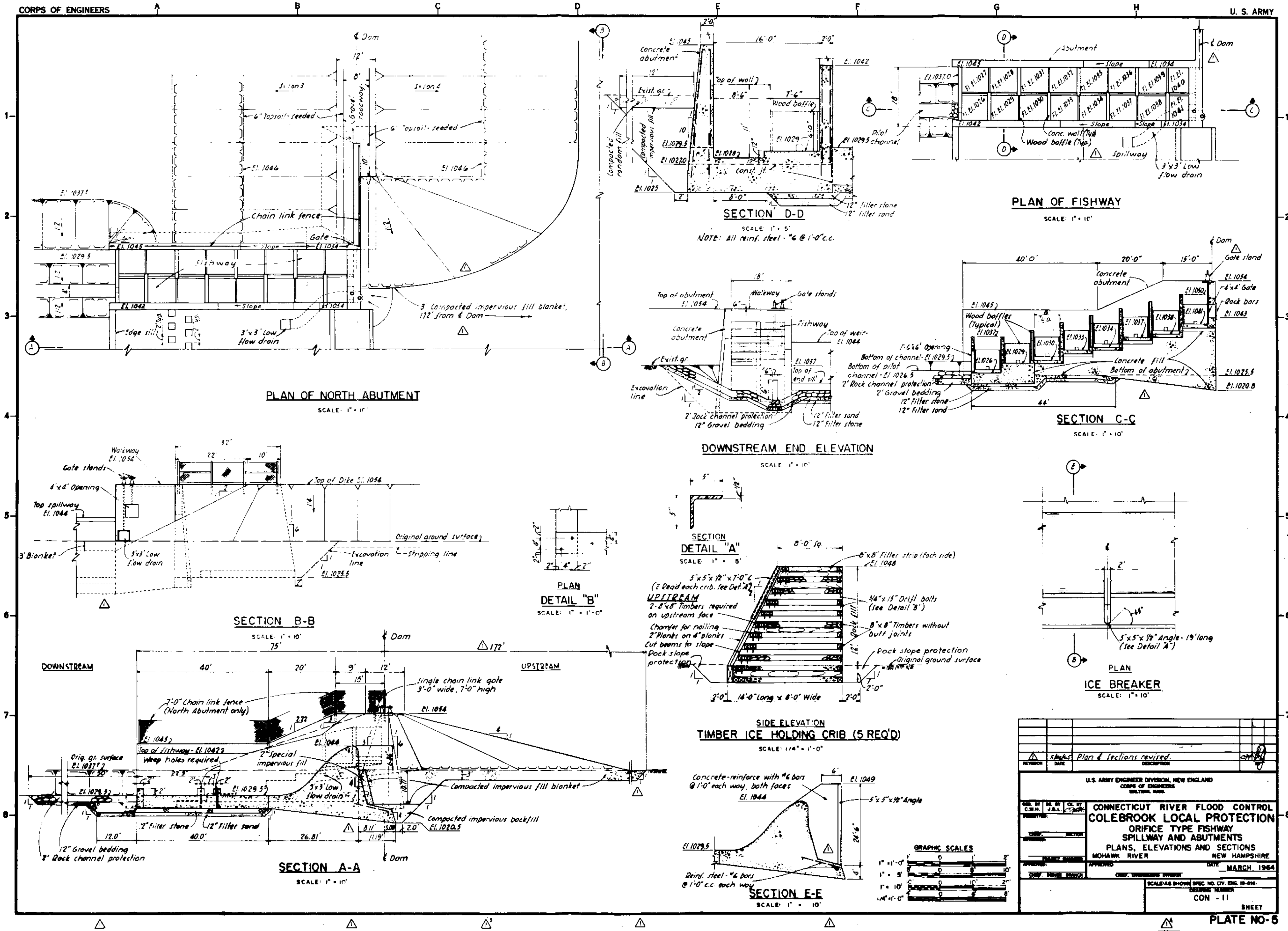
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
DAM AND SPILLWAY CHANNEL
PROFILE AND SECTIONS
MOHAWK RIVER
NEW HAMPSHIRE
MARCH 1964
CON - 11

PLATE NO-4



Plan & Sections revised

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
ORIFICE TYPE FISHWAY
SPILLWAY AND ABUTMENTS
PLANS, ELEVATIONS AND SECTIONS
MOHAWK RIVER NEW HAMPSHIRE

DATE MARCH 1964

CON - 11

PLATE NO-5

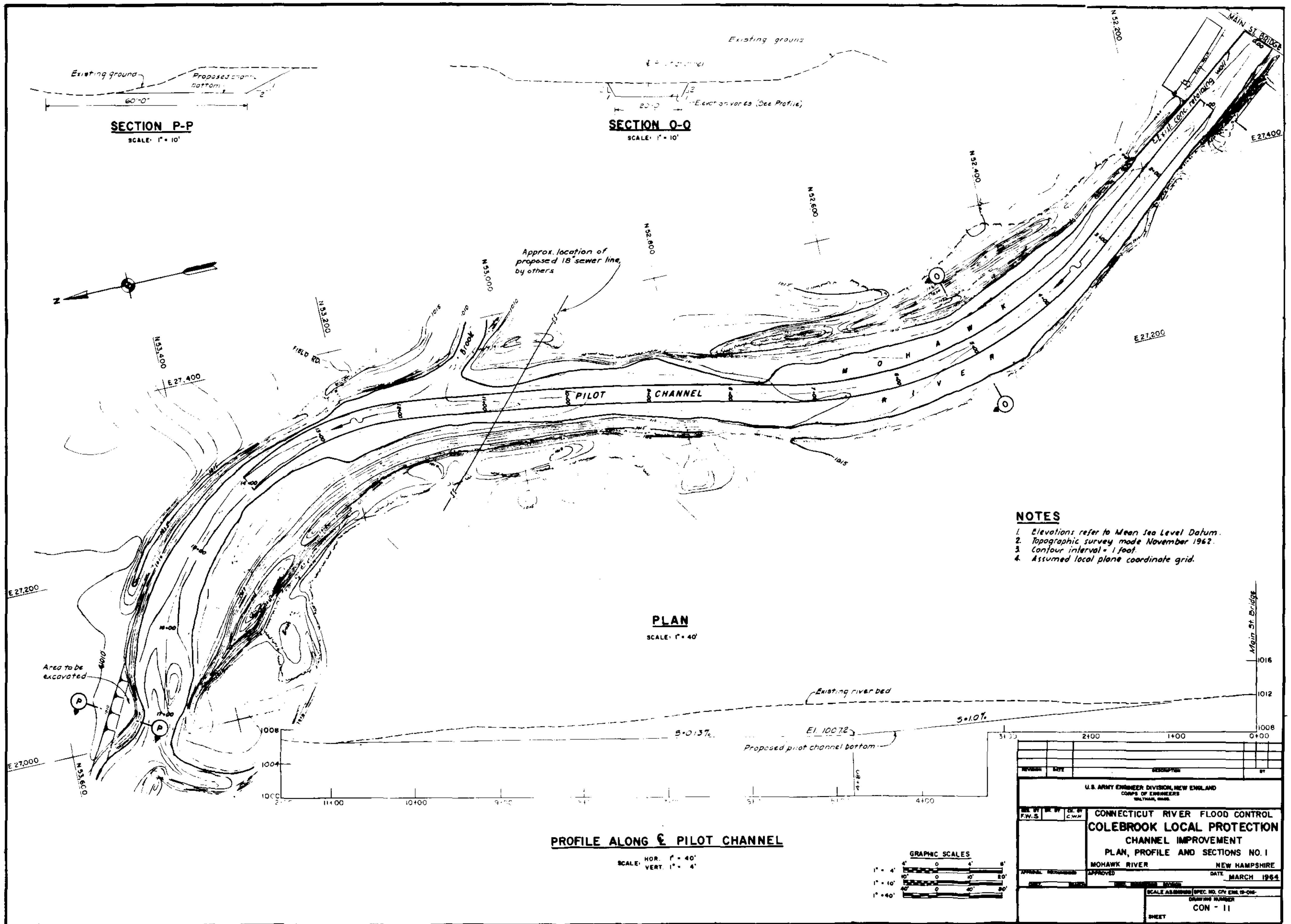

SECTION P-P
SCALE: 1" = 10'
Existing ground
Proposed channel bottom
60'-0"
SECTION O-O
SCALE: 1" = 10'
Existing ground
Elevation varies (See Profile)
20'-0"
MAIN ST. BRIDGE
Exist. conc. retaining wall
N 52,200
N 52,400
N 52,600
N 52,800
N 53,000
N 53,200
N 53,400
N 53,600
E 27,400
E 27,200
E 27,000
Approx. location of proposed 18" sewer line, by others
FIELD RD.
Brook
PILOT CHANNEL
MOHAWK RIVER
Area to be excavated
NOTES
1. Elevations refer to Mean Sea Level Datum.
2. Topographic survey made November 1962.
3. Contour interval = 1 foot.
4. Assumed local plane coordinate grid.
PLAN
SCALE: 1" = 40'
Main St. Bridge
Existing river bed
S=0.13%
El. 1007.2
S=1.0%
Proposed pilot channel bottom
1016
1012
1008
1004
1000
11+00
10+00
4+00
2+00
1+00
0+00
PROFILE ALONG ℄ PILOT CHANNEL
SCALE: HOR. 1" = 40' VERT. 1" = 4'
GRAPHIC SCALES
1" = 4'
1" = 10'
1" = 40'
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
F.W.S.
C.W.H.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
CHANNEL IMPROVEMENT
PLAN, PROFILE AND SECTIONS NO. 1
MOHAWK RIVER
NEW HAMPSHIRE
APPROVED
DATE MARCH 1964
DRAWING NUMBER
CON - 11
SHEET

PLATE NO-6

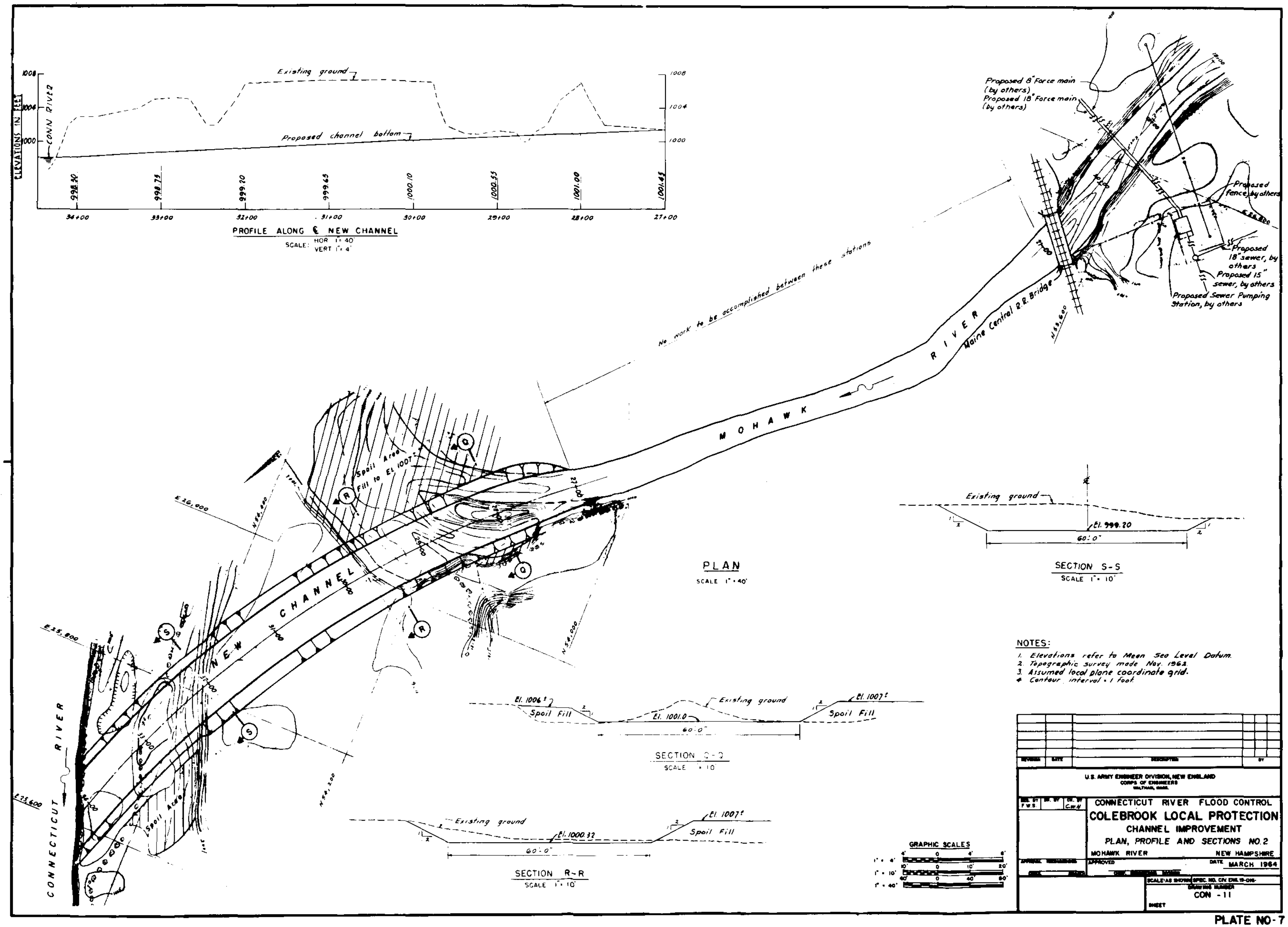
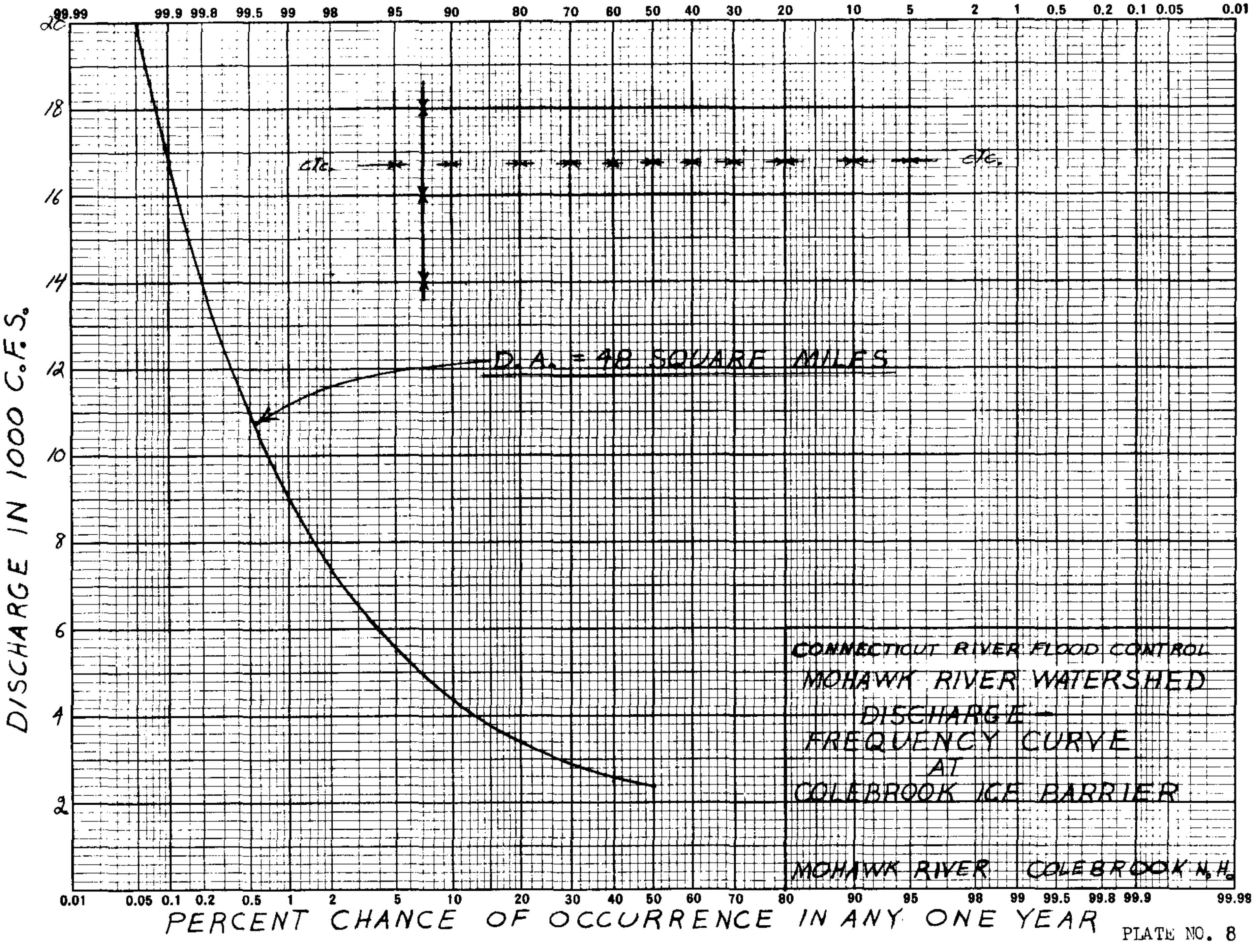
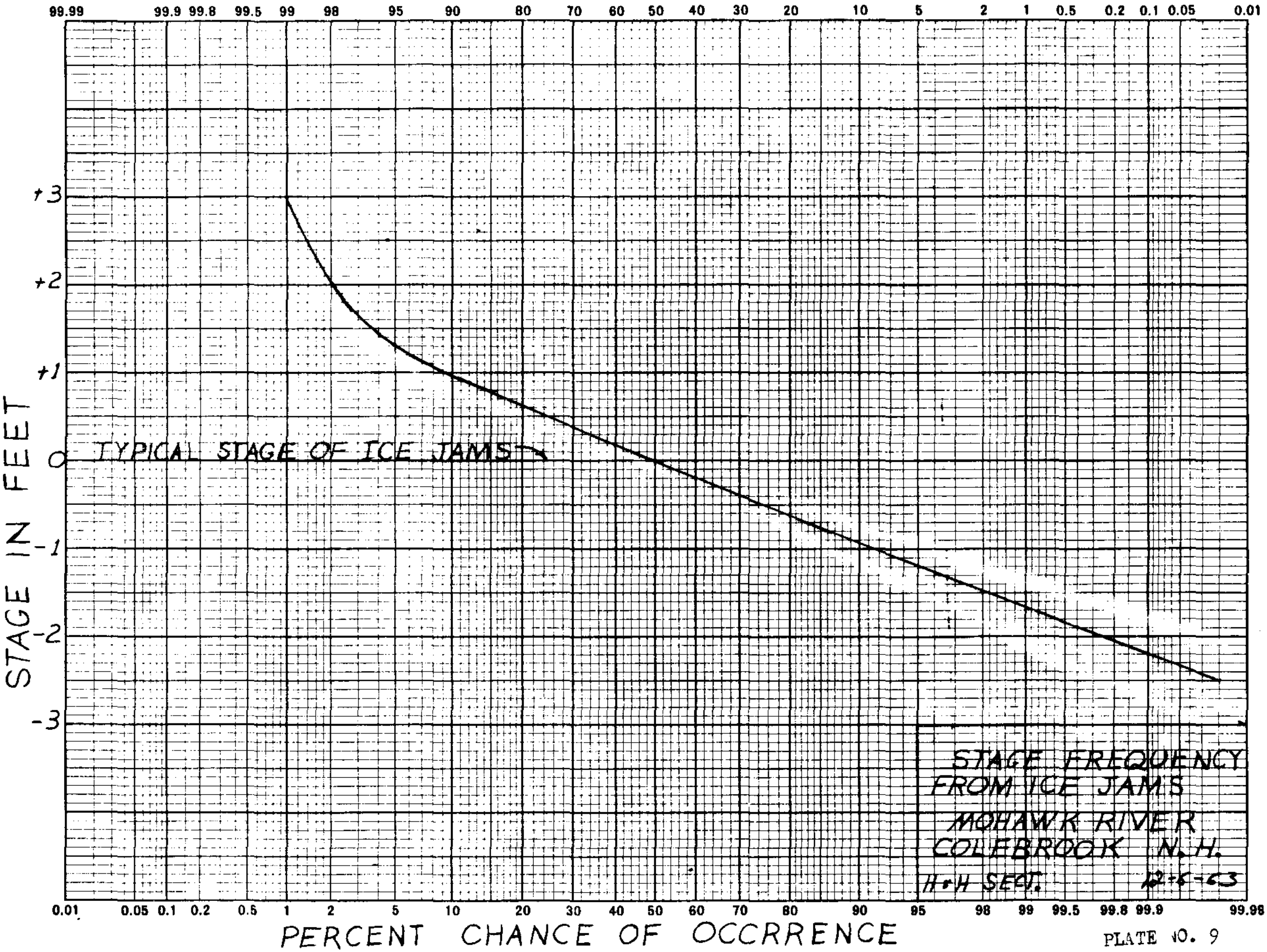

Existing ground
Proposed channel bottom
ELEVATIONS IN FEET
CONN RIVER
1008
1004
1000
998.30
998.75
999.20
999.65
1000.10
1000.55
1001.00
1001.45
34+00
33+00
32+00
31+00
30+00
29+00
28+00
27+00
PROFILE ALONG ℄ NEW CHANNEL
SCALE: HOR 1" = 40' VERT 1" = 4'
Proposed 8" Force main (by others)
Proposed 18" Force main (by others)
Proposed fence, by others
Proposed 18" sewer, by others
Proposed 15" sewer, by others
Proposed Sewer Pumping Station, by others
Maine Central R.R. Bridge
No work to be accomplished between these stations
MOHAWK RIVER
NEW CHANNEL
Spoil Area Fill to El. 1007±
Spoil Area
CONNECTICUT RIVER
PLAN
SCALE 1" = 40'
Existing ground
El. 999.20
60'-0"
SECTION S-S
SCALE 1" = 10'
NOTES:
1. Elevations refer to Mean Sea Level Datum.
2. Topographic survey made Nov. 1962.
3. Assumed local plane coordinate grid.
4. Contour interval = 1 foot.
El. 1006±
Spoil Fill
Existing ground
El. 1001.0
60'-0"
El. 1007±
Spoil Fill
SECTION Q-Q
SCALE 1" = 10'
Existing ground
El. 1000.32
60'-0"
El. 1007±
Spoil Fill
SECTION R-R
SCALE 1" = 10'
GRAPHIC SCALES
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
CHANNEL IMPROVEMENT
PLAN, PROFILE AND SECTIONS NO. 2
MOHAWK RIVER
NEW HAMPSHIRE
DATE MARCH 1964
CON - 11

PLATE NO-7



DISCHARGE IN 1000 C.F.S.
PERCENT CHANCE OF OCCURRENCE IN ANY ONE YEAR
D. A. = 48 SQUARE MILES
etc.
etc.
CONNECTICUT RIVER FLOOD CONTROL
MOHAWK RIVER WATERSHED
DISCHARGE-
FREQUENCY CURVE
AT
COLEBROOK ICE BARRIER
MOHAWK RIVER COLEBROOK N.H.

PLATE NO. 8



99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
+3
+2
+1
0
-1
-2
-3
STAGE IN FEET
TYPICAL STAGE OF ICE JAMS
STAGE FREQUENCY FROM ICE JAMS
MOHAWK RIVER
COLEBROOK N.H.
H+H SECT.
12-6-63
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
PERCENT CHANCE OF OCCRRENCE

PLATE NO. 9

APPENDIX A

LETTERS OF CONCURRENCE AND COMMENT

Exhibit No.	Agency	Letter Dated
1	Town of Colebrook, New Hampshire Approval of Board of Selectmen	February 14, 1964
2	U. S. Department of the Interior Fish and Wildlife Service	May 29, 1963
3	U. S. Department of the Interior Fish and Wildlife Service	January 31, 1964
4	U. S. Department of the Interior Bureau of Outdoor Recreation	January 15, 1964
5	State of New Hampshire Water Resources Board, including;	January 21, 1960
5A-5M	Report and Letters from residents to Board of Selectmen	

TOWN OF COLEBROOK
New Hampshire
OFFICE OF THE SELECTMEN

Refer to file no.
NEDED-D

February 14, 1964

Mr. John Wm. Leslie
Chief, Engineering Division
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Mr. Leslie:

The Board of Selectmen have reviewed the studies that your division has made of the existing ice problem here in Colebrook. To say that we are amazed that you were able to obtain so much accurate information with so little field work would be an understatement. As laymen, of course, we are not able to comment too much on the construction details. However, we can locate in your studies where you have designed features to correct the problems as we related them to you verbally, and as we pointed them out to your engineers during their site inspections. In addition, we see some very obvious features that we completely overlooked.

On February 10, 1964, the Board unanimously adopted a resolution that the Town of Colebrook would provide the items of cooperation listed in your letter of February 3, 1964, and as required by Section 205 of Public Law 87-874. In addition, the selectmen will request the voters of the Town pass a similar resolution at the Annual Town Meeting which will be held March 10, 1964. We have no fear about the resolution being adopted due to the fact that voters at the last Town Meeting authorized the selectmen to purchase any land required for this project by raising the money through short term loans. This vote was given to allow the selectmen to proceed should any action be required between Town Meetings.

Finally, Mr. Leslie, the Board wishes to acknowledge their gratitude to you and your staff for these studies. Of course, Colebrook could not possibly undertake this project by itself. We certainly hope that the approving authorities will find this project feasible. Everyone acquainted with the problem realizes that it is essential, but as stated above it is simply beyond our economical means.

Sincerely yours,

OFFICE OF THE SELECTMEN

Beaton Marsh

Beaton Marsh, First Selectman

BM/dj.

EXHIBIT NO. 1

Town Of Colebrook, New Hampshire

OFFICE OF THE SELECTMEN

March 25, 1964

Mr. John Wm. Leslie
Chief, Engineering Division
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Reference: Your file No. NEDED-D

Dear Mr. Leslie:

As stated in our letter of February 14, 1964, a resolution was presented to the voters of the Town of Colebrook at their Annual Town Meeting, March 10, 1964. The entire proposed project was presented during the discussion of Article 34 of the Official Town Warrant. Article 34 read as follows:

> To see if the Town will vote to authorize the Selectmen to purchase the land necessary for the proposed ice control project now under study by the U. S. Engineers, if said project is approved by the U. S. Government, from the present landowners or the State of New Hampshire, whichever is to the best interest of the Town and to appropriate the sum of $20,000 or authorize the Selectmen to negotiate a short term loan for a sum not exceeding $20,000.

Prior to the meeting the preliminary drawings were posted in the Town Hall. All three selectmen were present to describe the drawings before and after the formal Town Meeting. As the polls were open until 6:30 P. M., all those who voted were exposed to the project and it seemed that a large majority there present were most interested. It would be impossible to state the number of voters that stopped, looked over the project, and asked questions. However, it can be stated that at least one selectman was required to answer the questions all day long except when the formal meeting was in session.

During the formal meeting, the entire project was discussed. The following topics were explained:

1. Purpose of project.
2. Results of preliminary studies.
3. Proposed construction.
4. How the proposed project would control the ice problem.
5. How the project would be financed.
6. Town's responsibility.
7. Benefits that the Town would derive.

When the town's responsibilities were discussed, the four items listed on your letter of February 3, 1964, were read verbatim. It was explained that the Town must accept these items to comply with Section 205 of Public Law 87-874.

The Town approved the provision to provide land and easements at no cost to the United States by approving the above Article in the Town Warrant. A voice vote was taken and there were not any dissenting votes. A copy of the Town Clerk's statement is attached.

As for the other three items, they were presented in a form of a resolution which passed without any dissenting votes.

Questions were asked as to the operation of the recreation facilities in the proposed project. The answer was that the details would have to be in accordance with the regulations established by the Secretary of the Army. However, being a public project, we could assure them that the public would certainly derive the benefits. The interest shown was due to the fact that there is no public bathing within twenty-six miles of Colebrook. The cost to use the private pool is fifty cents per day per child. Not many families can afford that much for bathing.

Concern was shown should the project exceed $1,000,000. It was explained that from all preliminary studies this seemed most unlikely.

As stated above, after much searching and discussion, the resolution passed without any dissenting votes.

Very truly yours,

OFFICE OF THE SELECTMEN

Beaton Marsh

Beaton Marsh, First Selectman.

BM/dj.

Enclosure.

Town Of Colebrook, New Hampshire

OFFICE OF THE SELECTMEN

The following two warrants were presented to the voters of Colebrook at the annual town meeting of March 10, 1964

Article 3 To see whether the Town will vote, by ballot with use of check-list pursuant to R.S.A. 38:5, that it is expedient for the Town of Colebrook to acquire the plant of the Colebrook Water Company.

Results of the ballot vote: 453 YES 84 NO 45 NO VOTE

Article 34 To see if the Town will vote to authorize the Selectmen to purchase the land necessary for the proposed ice control project now under study by the U. S. Engineers, if said project is approved by the U. S. Government, from the present landowners or the State of New Hampshire whichever is to the best interest of the Town, and authorize the Selectmen tp negotiate a short term loan for a sum not exceeding $20000.

Result of the vote: APPROVED

Robert W. Moore

Robert W. Moore
Town Clerk

Supplement, Exhibit No. 1

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON 11, MASSACHUSETTS

May 29, 1963

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This constitutes our conservation and development report on the local ice-jam flood protection project located on the Mohawk River at Colebrook, New Hampshire that your office is studying under authority of Section 205 of Public Law 87-874. This report was prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), in cooperation with the New Hampshire Fish and Game Department. That agency concurs in the report as indicated in its letter of May 2, 1963. A conference attended by representatives of the New Hampshire Fish and Game Department and this Bureau in your office on March 20, 1963 was devoted to fish and wildlife aspects of the project.

The purpose of the project is to hold back frazil-ice and surface-ice that form upstream from the center of Colebrook. Channelization downstream would enable sections of cover-ice to float away rather than to jam up along the existing shallow river bed.

It is our understanding that the project may consist of 32-foot earth-filled dam abutments with a concrete spillway that will measure 120 feet in width and 14 feet in height. A sluice gate providing complete draw-down opportunities would be included. The dam would be located immediately upstream from the Town of Colebrook. This location is approximately one mile above the confluence of the Mohawk River and the Connecticut River. A permanent pool of about 13 acres is being considered. Maximum depth would be about 13 feet. A major portion of the pool, however, would be 4-6 feet deep.

The stream would be realigned and deepened downstream from the Main Street Bridge for a distance of .5 miles. The bridge is about one-half mile below

EXHIBIT NO. 2

the project. The broad gravel-rubble river bed, approximately 70 feet wide at present, would have a pilot channel width of 20 feet, provided with 2:1 side slopes and deepened to carry four feet of water during the low flow season.

A significant cold-water fishery is involved in this project. The moderate to heavily utilized fishery is located both in the Mohawk River and in the Connecticut River. The principal species are rainbow trout, brook trout, and brown trout; of these, rainbow trout is the most important.

In addition to supporting trout fishing, the Mohawk River is a major spawning tributary for fish from the Connecticut River. Spring runs of rainbow trout start in the Mohawk River when water reaches 50 degrees in about mid-April and continue into May. Fall runs of other species occur from about September 15 to October 15.

The trout fishery in the Connecticut River is located between the confluence of the Upper Ammonoosuc River and Lake Francis. This 30-mile reach provides some of the finest big-river trout fishing in New Hampshire. The main-stem trout fishery is sustained by natural reproduction from the Mohawk and other tributaries, but this is supplemented by some stocking in these areas.

The effect of the project would not be significant on wildlife resources.

Since the Colebrook dam would be located near the mouth of the Mohawk River, it would prevent spawning fish from reaching much of the spawning area in this important tributary.

It is, therefore, essential that an adequate fish passage facility be included in project design so that fish can reach those waters upstream from the dam. A fish-passage facility would minimize losses to the trout fishery in both the Mohawk and Connecticut Rivers.

At the March 20 conference it was agreed that such a facility would be designed by the New Hampshire Fish and Game Department and that these plans would be presented, discussed, and modified for incorporation in your plans at a subsequent meeting. At this meeting your office also agreed that a pilot channel providing an adequate amount of attraction water to the foot of the fishways would be incorporated as a project feature. This feature would also be designed in cooperation with the New Hampshire Fish and Game Department.

The pool created by the dam would provide a limited trout fishery. Warm water resulting from creation of the small shallow pool would not affect spawning fish movement appreciably. Pool waters would normally be cool during these periods.

Initially, we expressed concern about the proposed channel work. After full exploration into the effects of concentrating the flow and increasing the water depth, we find that the channel work should improve the present situation. Resultant water conditions should be beneficial to fish ascending the stream to spawn. While it is expected that most of the new channel will be entrenched in gravel, there may be sections where silt or bedrock is exposed, causing loss of spawning beds. Representatives of your office have assured us that, should this occur, these bottom sections will be finished with a layer of gravel to replace destroyed spawning beds.

Although the major portion of the construction activity will be dry, some of this activity could cause silting in the stream that would damage spawning beds and fish populations in the Mohawk and Connecticut Rivers. Your office has advised us that all feasible measures would be taken during construction to minimize the entrance of silt into the stream. If it appears that silting conditions may become critical, it may be necessary to construct silt barriers downstream from the dam. Careless gravel washing operations, topsoil stripping, and reshaping of stripped banks all could result in excessive silting of the stream.

We recommend--

1. That a fishway designed in accordance with mutually acceptable plans be incorporated in the dam.

2. That measures be taken, including installation of silt barriers if necessary, to prevent stream siltation insofar as possible during project construction.

Your office has been most cooperative and considerate of fish and wildlife interests in connection with the development of project plans.

Sincerely yours,

John S. Gottschalk
Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON 11, MASSACHUSETTS

January 31, 1964

Division Engineer
U.S. Army Engineer Division, N.E.
Corps of Engineers
424 Trapelo Road
Waltham 54, Mass.

Dear Sir:

This constitutes a supplement to our May 29, 1963 conservation and development report on the local ice-jam flood protection project located on the Mohawk River at Colebrook, New Hampshire, that your office is studying under authority of Section 205 of Public Law 87-874. This report was prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.), in cooperation with the New Hampshire Fish and Game Department, and has the concurrence of that agency as indicated by letter dated January 29, 1964.

Mr. Leslie's letter of December 31, 1963 advised us of two changes in the engineering planning for this project and solicited our comments.

We understand that the project plans are essentially the same as discussed during previous meetings with your staff and on which our May 29, 1963 report was based, except for the following two items:

1. The concrete spillway has been increased from 120 feet to 212 feet, effecting a four-foot reduction in the height of the dam.

2. Local interests have requested the inclusion of recreation at the permanent 14-acre pool required for ice protection.

In our May 29, 1963 report we stated that a permanent pool of about 13 acres was being considered. Maximum depth would be about 13 feet. A major portion of the pool, however, would be 4-6 feet deep. We understand that the same pool at the same location is still being considered except the surface area is now defined as 14 acres.

EXHIBIT NO. 3

The modifications in project plans will not require any change in our conservation and development report of May 29, 1963 wherein it was recommended--

1. That a fishway designed in accordance with mutually acceptable criteria be incorporated in the dam.

2. That measures be taken, including installation of silt barriers, if necessary, to prevent stream siltation insofar as possible during project construction.

Sincerely yours,

John S. Gottschalk
Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
Northeast Regional Office
U. S. Court House
9th and Chestnut Streets
Philadelphia, Pennsylvania - 19107

L7423

January 15, 1964

Your Reference:
NEDGW

Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

We refer to your letter of December 2 and attachments concerning the "Detailed Project Report" you are preparing for a local flood control project in Colebrook, New Hampshire.

It is our understanding that the project, located on the Mohawk River, will consist of an earth dam with a concrete spillway which includes an orifice type fish ladder. Completion of the project will act to reduce the spring flooding downstream in the built-up section of town, which is caused by ice jams. A 14-acre permanent pool will be part of the project.

The recreational values and possible uses which were apparent in this project were discussed in a preliminary way, during the early phases of your study, between Mr. Ignazio of your staff and Mr. Dupee of our Office. It was brought out at that time that the recreation potential of the project could help meet the needs of the local population, for a nearby picnicking and swimming area. According to your letter, this thinking was supported by local officials, who have expressed an interest to you in utilizing this potential by requesting that recreational facilities be incorporated in the project. The contemplated recreational facilities would include development for such activities as swimming, picnicking and those associated facilities necessary, such as, access, parking and sanitary systems.

Our preliminary estimate of the costs necessary to provide facilities required for a Design Load of 300 based on 13,000 visitor days is lower than the figure of $70,000 given in your letter. Two factors may have created this difference, our figures would not include the cost of lands needed for placement of facilities and access to the pool and your own studies may have progressed to a point where a firm cost basis was possible to develop. This second factor is, of course, a further refinement of the figures we are normally able to furnish.

We have used the provisional method outlined in the Evaluation Standards for Primary Outdoor Recreation Benefits, prepared by the Joint Task Force on Recreation of the Recreational Advisory Council and the Ad Hoc Water Resources Council to arrive at the following possible benefits.

Year	Recreation Days	Benefit Value	Recreation Benefits
Completion	13,000	1.00	$13,000

We would like to point out that in our normal relationships, we would be unable to provide assistance to you in evaluating the recreation potential of small projects such as this. Our principal consideration in assisting you in your evaluation of this site was that undoubtedly in the future, you will undertake studies of similar small projects that would readily adapt themselves to helping to meet the recreational needs of a local population. With this thought in mind, we are hopeful that our mutual efforts on this project will assist you in similar studies in the future.

Sincerely yours,

John Sullivan

John Sullivan
Regional Director

STATE OF NEW HAMPSHIRE

WATER RESOURCES BOARD

STATE HOUSE ANNEX
CONCORD

January 21, 1960

U. S. Army Engineer Division
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention - Mr. Shanahan:

Gentlemen:

I am enclosing copies of letters sent to the Board of Selectmen of Colebrook regarding the damages caused by the Mohawk River ice jam flooding.

We have not investigated the statements in these letters and such figures as are given may be too high or too low. In any case, we are sending them along for your information.

We will be pleased to try to furnish you further information if necessary.

Very truly yours,

Leonard R. Frost
Water Resources Engineer

lrf:c
encls.

EXHIBIT NO. 5

MEMORANDUM

SUBJECT: Mohawk River Channel Improvements, Colebrook, N. H.

The New Hampshire Water Resources Board was requested by the Selectmen of Colebrook, New Hampshire to investigate the frequent occurrence of minor flooding on the lower reaches of the Mohawk River and obtain remedial action.

The flooding is mostly caused by ice jams which occur between the main street and the railroad track. Some topography was obtained and a possible solution considered. To obtain an estimate of size and cost of project, a new channel was considered for a distance of 1300 feet starting from a point 625 feet downstream of the Main Street bridge plus provision for Beaver Falls Brook. Fifteen foot bottom width and 1 on 5 side slopes were used for a section. The narrow bottom width was used to reduce the volume of formation of anchor ice. Such a project would cost in the vicinity of $20,000 and should reduce ice jamming by maintaining uniform velocity and cross section. However, it is doubtful if complete elimination of ice jamming could be guaranteed.

The New Hampshire Water Resources Board requested the Town officials for information as to nature and money value of damages. The information furnished indicated a damage figure of $2,700 plus other non-assessed damages for the last flood occurrence. As flooding occurs about two out of three years, it is probable that an annual damage figure would be approximately $2,000.00.

Discussion with Town officials indicate that the land may be readily obtained for the project purposes. Land to be taken would be relatively of low value.

Leonard R. Frost
Water Resources Engineer

Sept. 1, 1959

Selectmen of the Town of Colebrook
Colebrook, N.H.

Gentlemen:

Before another spring thaw arrives, I would like to list a few of the inconveniences that Igo through ev ry spring with the high water situation that we have in this locality.

I realize that Colebrook taxpayers are at the present and probably quite a few years from now will be taxed (property-wise) to the limit of which they can stand, there being no industry here. Therefore forthwith I make a list of my highwater problems which might be considered if and when the money might be available.

1. Water gets into the basement that is used for storage of fresh vegetabled.
2. Water damage requires the servic s of plumbers and electricians to take apart and clean refrigerator, compressors and oil burner.
3. Due to the fact that the heating unit has to be shut off during this period every spring and the business has to be closed and the apartment upstairs is without heat at that time, we have to find a place to take the children during this time.
4. Each year damage is done to the buildings by the ice hitting and breaking the cornet boards, clapboards, and fence from back of the building.
5. It takes the basement about a couple of months to dry out and in the meantime the windows stay steamed up which is not especially attractive to place of business.
6. The course of the river has shifted onto my side of the river of my place of business and has washed under the footing of the foundation.
7. The cement retaining wall on the opposite side of the river from my place of busiess has cracked and crumbled from dymaniting the ice in the spring, year after year until the wall is ready to fall into the river.

I reali_e that the complaints are numerous on this high water situation in this town, but I feel that the above listed complaints may somewhat slarify my feelings in regards to this situation.

Very truly yours,

Dean S. Howard

Dean B. Howard

Restaurant next to river

EXHIBIT NO. 5-A

Colebrook, N. H.

November 17, 1959

Selectmen, Town of Colebrook
Colebrook, N. H.

Gentlemen:

Every spring when the river overflows, the land in back of my station is flooded and my cellar floor is always covered to a depth of about eight inches.

This means that I have to keep a pump running to help keep out the water as well move everything stored in the cellar.

If some means could be found to keep the river within it's banks it would eliminate a lot of work for all the residents in this area.

Very truly yours,

Hercules J. Lemieux

Filling station next to hotel

EXHIBIT NO. 5-B

Colebrook, N. H.
November 17, 1959

Selectmen
Town of Colebrook
New Hampshire

Gentlemen:

I wish to complain about the flood conditions of the Mohawk River, regarding damage to Monadnock Congregational Church Colebrook.

During the flood of last spring and twice before, the water has run back into the cellar and it was necessary to remove the blower from the heating system and also dismantle the stoker and clean it all out to prevent damage from the water. It was also necessary to have a "watch" posted there constantly to check the two pumps we had to have to keep the water down.

I realise that the property is not taxable, but is supported by taxpayers of this community.

I hope something can be done to remedy this situation.

Respectfully yours,

Frank H. Owen

Frank H. Owen,
Chairman, Board of Trustees

EXHIBIT NO. 5-C

ELECTRICAL SUPPLIES

WALL PAPER
PAINTS
TOYS

Bryant's

COLEBROOK, N. H.

Nov. 18, 1959

STATIONERY
TOILET GOODS
LADIES
MEN'S, BOYS' AND
CHILDREN'S
WEAR

Board of Selectmen
Colebrook, N. H.
Attention: Beaton Marsh, Chairman

Dear Mr. Marsh:

In connection with the Mohawk River, it is my opinion that if there is not something done to straighten and deepen this river we are all going to suffer some more heavy damages.

At various times they have blasted until our walls have become broken and in my opinion its only a matter of a short time until these walls will colapse. Then we will be in for a real flood.

Having lived on the bank of this river for twenty five years, I have noted that the past few years the ice jams have become more each year until we have suffered some very heavy losses.

I strongly recommend that something be done at once to save this end of the town.

Yours very truly

BRYANTS

By Bert Bryant

FEB:h

EXHIBIT NO. 5-D

IN THE CENTER OF THE "NORTH COUNTRY"

The Colebrook House and Motel

COLEBROOK - NEW HAMPSHIRE

November 18, 1959

Board of Selectmen,
Colebrook, New Hampshire

Gentlemen;-

I will now put in writing the request that I have made verbally to the various Selectmen so many times during the past year, namely, that something be done immediately to alleviate the annual ice and flood threats and damages from the Mohawk River.

I have just paid my tax bill in the amount of $2,445.30 which was based on your assessment of our land and buildings. Part of this land has been repeatedly flooded and damaged. Last spring when the most serious flooding occurred, the entire Mohawk River was diverted across this land for more than 24 hours. The Motel building on the land received only minor damage but, if it had not been for the driveway fence and snow bank from plowing, the ice would have seriously damaged, if not completely destroyed, the building. In the hotel basement, it was necessary to have a plumber standing by for approximately 24 hours with two pumps in order to keep the water level down so that heat could be maintained.

It seems completely unfair to continue this rate of taxation if the flood threat is not eliminated, and a rebate should be made for this year. Furthermore, our plans for additional buildings on the land can not be carried out while this condition exists. In both instances, the town suffers - a current tax loss and a potential tax loss.

Very truly yours,

Raymond M. Hull

Raymond M. Hull,
Treasurer.

EXHIBIT NO. 5-E

C. C. CUMMINGS Inc.

Telephone 68 Colby Street

COLEBROOK, N. H.

[illegible] 18.1959

Selectmen
Town Of Colebrook
Colebrook,N.H.

Gentlemen.

I have lived at my present home on Acadamy Street for three years and the Mohawk river has flooded over two out of the three years.

The first year the river caused consederable damage to my cellar walls,heating plant and other items that were in the cellar.The second year I was a little more fortunate as I got the oil burner and everything out of the cellar.

This situation has caused me considerable expense and I believe that there is absolute no need of it reoccuring if the town or somebody would do something about dredging the river.

I would appreciate your giving this your immediate attention so that this will not happen again this year.

Yours truly

Ben Hawkins

Benjamin Hawkins

EXHIBIT NO. 5-F

PLUMBING HEATING VENTILATING

FULLER BROTHERS

TELEPHONE 155

COLEBROOK, NEW HAMPSHIRE

November 18, 1959

Board of Selectmen
Colebrook, N. H.

Gentlemen:

Due to past experience we are strongly convinced that during each winter and spring we are constantly in danger of substantial damage resulting from flood waters caused by ice jams forming adjacent to our property here in Colebrook,

As a result of such flooding in 1956 we lost over $2,000.00 worth of stock and there was again a loss during the winter of 1958 and 1959.

You are probably aware of the fact that insurance to cover this particular loss is unavailable to us.

Anything that you can do to correct or relieve this situation will be greatly appreciated.

Very truly yours,

FULLER BROTHERS

HEP:h

By Harold E. Plant

EXHIBIT NO. 5-G

11/18/59

Dear Mr Marsh.

I called Harold Stevens last nite and this is the information he had to offer.

The extent of damage due to high water last spring was over $300. It could have been more but he was able to do some of the necessary labor himself.

It would be difficult to estimate any future cost - but possibly the above can be some guide.

Before he had fill (loam) put in between river and house water would come into the cellar every thaw and necessiate removal of oil burner.

Very Truly
Scott Graves.

If you would like more concrete facts you could contact Harold in Lisbon NH

Dry Cleaning Establishment

EXHIBIT NO. 5-H

Colebrook N. H.
Nov. 18 1959

To the Selectmen of Colebrook N.H.

In reply to your request for the damage to my property due to water, ice and debris, I submit a conservative estimate of from four to five hundred dollars in the spring of 1959

M. H. Woodrow

Filling Station

EXHIBIT NO. 5-I

SUPERVISORY UNION NUMBER 7

State of New Hampshire

ERNEST B. DANA, SUPERINTENDENT

CLARKSVILLE
COLEBROOK
COLUMBIA

PITTSBURG
STEWARTSTOWN

COLEBROOK, N. H.

November 20, 1959

Mr. Beaton Marsh
Chairman of Selectmen
Colebrook, New Hampshire

Dear Beaton:

With the completion now of the new addition to the Colebrook Academy building, which means that three large classrooms and two toilets have been added to the vital service quarters and storage areas here in the old building on the basement floor level, and the fact that this floor is just about on a level with the bed of the Mohawk River only approximately 100 feet away, we are extremely concerned about the school's safety from floods. Our agriculture building, also, is extremely vulnerable to the same danger as it is constructed on a concrete slab which is only a few feet above the basement floor here in the main building.

All of us who have lived for any length of time in this area well know that following any cause for high water, such as a heavy rain or a big spring thaw, that this stream, which drains a relatively narrow valley with a decided westward pitch, can rise to a dangerous flood stage in an alarmingly short time. Twice during the past ten years we have escaped having the basement flooded only by a matter of inches. Each time it was averted only by dynamiting the ice jam piled up in the bend of the river directly opposite the building.

In light of what has been stated above, anything that can be done to control the water flow of this nearby and low bank river during the entire year, and which will reduce the existing ever present hazard, will be appreciated greatly.

Sincerely yours,

Ernest B. Dana

Superintendent

EBD:imh

EXHIBIT NO. 5-J

TELEPHONE 95 AMBULANCE SERVICE

Newman Funeral Service

Robert W. Moore

COLEBROOK, NEW HAMPSHIRE

November 30, 1959

Board of Selectmen
Colebrook
New Hampshire

Gentlemen,

This is to advise you that I had much water in my cellar last spring due to the ice jam on the Mohawk.

The water caused considerable damage to various supplies that I use in my business, which I had stored in the cellar.

I had a building in the back yard that I used to store equipment, the water was so high that it moved the entire building.

I do hope that the town can take proper action so that this will not happen again.

Yours truly,

EXHIBIT NO. 5-K

Colebrook, N. H.
April 9, 1960

Board of Selectmen
Colebrook, N. H.

Gentlemen:

In connection with the Mohawk River, I strongly urge that something be done at the earliest possible date. Starting in back of the Bannister place and continuing on down to the Conn. River the river bed has gradually filled up until the river cannot take care of the ice flow in the spring. Only last year when the ice went out it overflowed the banks so that ice cakes were six to eight feet deep from in back of the Fuller place to the Main Street Bridge.

I would consider this a state of emergency as the cement walls are starting to cave in. It seems after the flood of 1929 some of the cement walls were put in on top of logs, the logs having rotted away until the water flows underneath and is undermining the banks. A number of years ago they blasted the ice just above the Main Street bridge and the cement walls, built on top of logs, cracked at that time.

I gave permission some time ago for two large steel rods to go from the retaining wall to my cellar and I have watched them and find that they are pulling my cellar wall out gradually. This wall has tipped toward the river at least five inches in the past two years, and one of the rods is broken. It is only a matter of a very few years until these walls will go into the river and then we will all be in for serious trouble.

I have watched these changes for the past twenty five years and for the past few years we have suffered some very heavy damages from the excess water and ice cakes.

It is my hope, along with all of the property owners along the Mohawk that this condition will be brought to the attention of the proper interested parties and that the condition will be corrected before it is too late.

Very truly yours,

BB:bh

Bert Bryant

Bert Bryant

EXHIBIT NO. 5-L

Nov. 18, 1969

[T]his is an estimate of Water [da]mage last Spring.

[Oi]l Furnace

[Chi]mney burner twice cleaning and repairs 75.00

All cellar Windows broken 15.00

Tools, Saws, Hand Saw, Plumbing tools. repairs and cleaning 210.00

Cement 20 bags wet. @1.15 23.00

Potatoes 20 bu. @ 2.00 40.00

Apples 41 bu @ 3.00 123.00

Fire Truck pumping water 15.00

there was four feet of water in the cellar Merton Hall

This list is things that were damage and water soaked. All tools. Motors had to be cleaned and dried out.

Potatoes were a complete loss and lot of apples. They rotted by being wet.

No heat for three days.

This is one of the times that happen last spring. Many times in the past this same thing has happened.

Merton Hall

7455

EXHIBIT NO. 5-H

APPENDIX B

FLOOD LOSSES AND BENEFITS

Plates

APPENDIX B

FLOOD LOSSES AND BENEFITS

1. DAMAGE SURVEYS

A detailed damage survey was made in early 1962 to determine the extent of damage that is sustained with each ice-jam flood in Colebrook. Upon investigation it was learned that flood stages produced by the ice-jams vary very little from year to year. Typical of all ice-jam floods is the one which occurred in March of 1960. Losses were referred to the stages of this flood crest. In addition, sufficient data was gathered to derive losses for stages three feet higher, the stage where damage begins, and intermediate stages where marked increases in damage occurs.

The damage survey consisted essentially of door-to-door interviews and inspections of residential, commercial and other properties affected by flooding. The recorded information included the extent of the areas flooded, description of properties, nature and amount of damages, depth of flooding, high water references and relationships to other flood stages. Damage estimates were generally furnished by property owners or tenants. Investigators used their own judgement in modifying these estimates and also made estimates where owner or tenant estimates were not available.

2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. The types of losses included residential, commercial and public. Primary losses were evaluated to include (1) physical losses such as damage to structures, machinery and stock, and the cost of cleanup and repairs, and (2) non-physical losses such as unrecoverable loss of business and wages, cost of temporary facilities and increased cost of operation. Losses resulting from physical damage and substantially all of the related non-physical losses were determined by direct inspection of flooded properties and evaluation by property owners and field investigators. For residential properties when estimates of non-physical losses were not available from the owner, estimates were based on an established relationship between physical and non-physical losses for similar properties in the survey and similar areas.

3. RECURRING LOSSES

Stage-damage curves, referenced to the typical ice-jam peak elevations experienced in the flood of 1960, were developed to reflect the magnitude of recurring losses at varying stages of flooding above and below the reference flood for the reach on the Mohawk River in Colebrook. The recurring losses used in development of the stage-damage relationship reflect the economic and physical conditions existing in Colebrook at the present time.

4. AVERAGE ANNUAL LOSSES

Recurring losses in the reach of the Mohawk River in the Village of Colebrook were converted to average annual losses to provide a basis for determining annual benefits to be used in economic evaluation of the recommended flood control project. The stage-damage curve for the reach was correlated with stage-frequency to produce damage-frequency relationships from which the annual losses were derived in accordance with standard Corps of Engineers practice. Plates B-1 and B-2 show the procedure used in converting recurring stage-damage curve data to a curve of damage-frequency. Average annual losses in Colebrook amount to $18,200.

5. ANNUAL BENEFITS

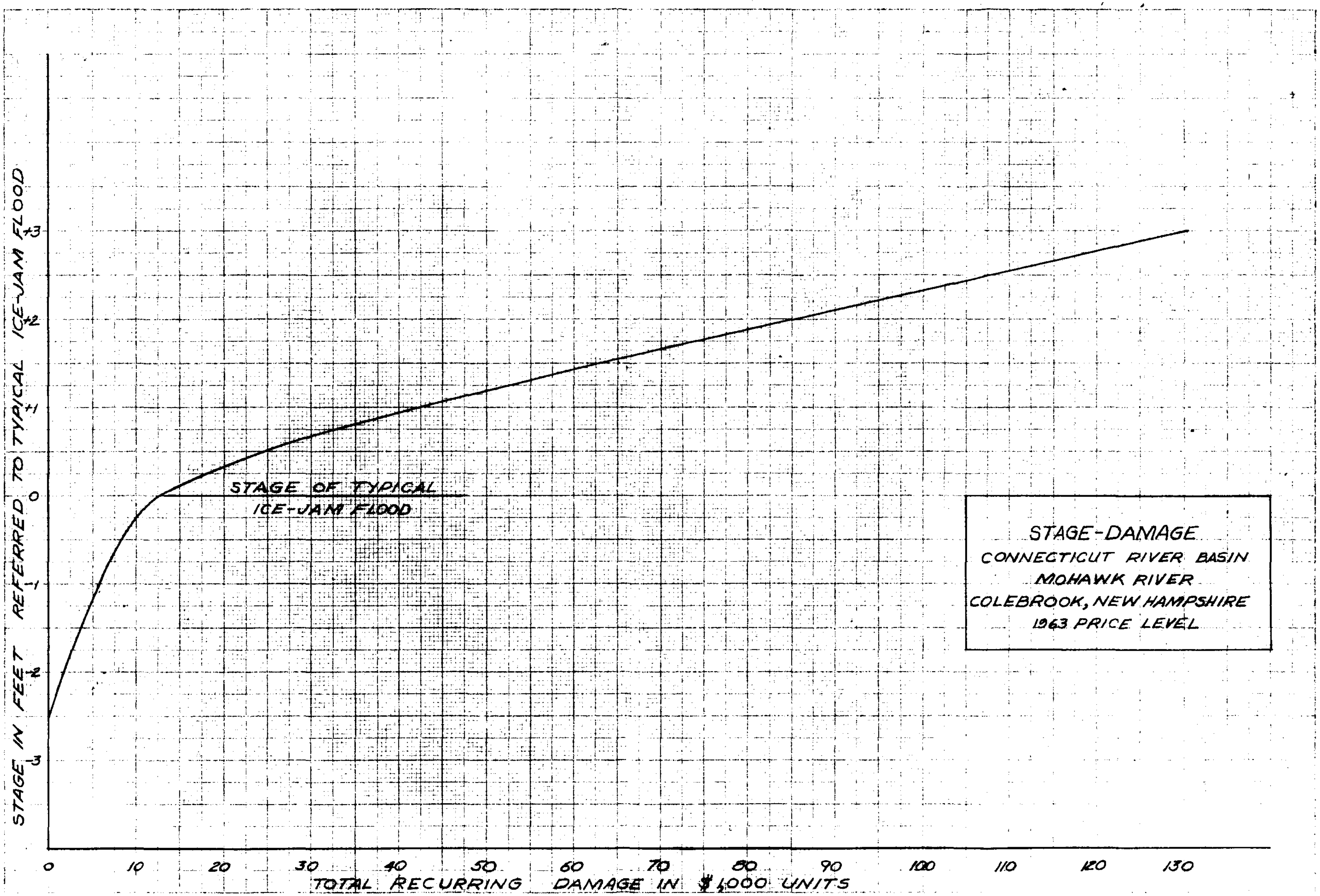
a. Flood Damage Prevention Benefits - Average annual flood damage prevention benefits were determined by deriving the difference between average annual losses under existing conditions and those losses remaining after construction of the protective works. Annual losses resulting from all floods having a frequency of more than once every 100 years will be eliminated by construction of the protective works. Average annual flood damage prevention benefits accruing to the project amount to $18,200.

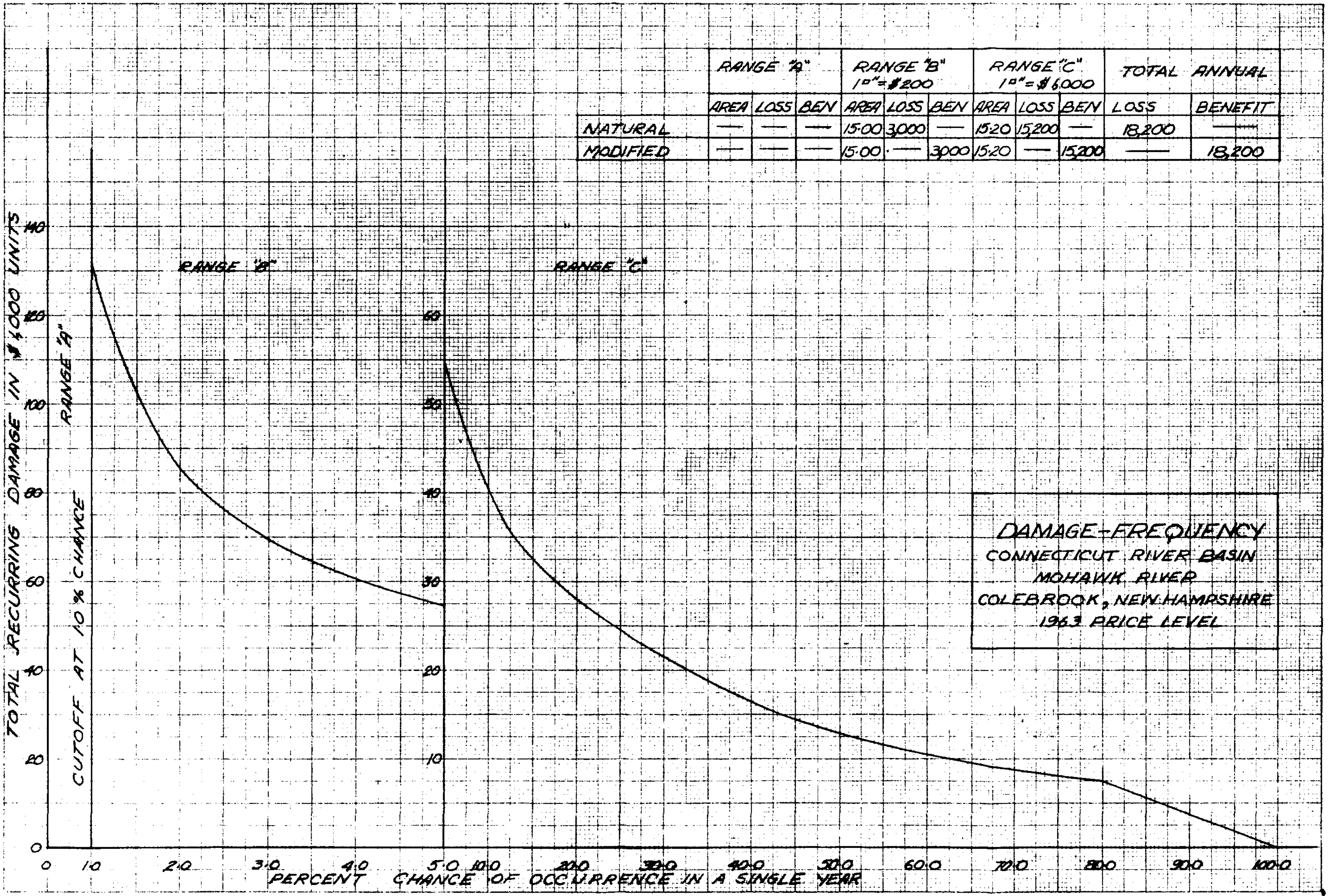
b. Other Tangible Benefits - No increase in utilization of lands and buildings is expected to follow construction of the project. Construction of the project would relieve the threat of flooding and encourage the present owners of the commercial and residential properties to remain in the area.

c. Redevelopment Benefits - Colebrook Dam is to be constructed in a portion of New Hampshire, Coos County, which has been named a Redevelopment Area by the Area Redevelopment Administration under Section 5b(6) of P.L. 87-27. Data obtained from the Bureau of Census, U. S. Department of Commerce and the Department of Employment Security of the State of New Hampshire indicate that the unemployment rate of Coos County is 70% greater than the national average. The construction will put to work residents of the area who are unemployed or underemployed and the wages thereto are considered a benefit under current policy. Division records for Civil Works construction over the past 9 years indicate that for the type of construction involved, the labor costs average 27% of the total contract cost. Based on present estimated construction cost of the project, the total labor cost would be $162,000. After discounting for the number of people who will be hired locally (90%) and for the number so hired who will be unemployed or underemployed (80%), a total labor benefit of $117,000 is creditable to the project. Expressed as an average annual equivalent benefit, this amounts to $4,700.

d. Intangible Benefits - The project would also provide significant benefits which are not susceptible to monetary evaluation. The dangers of disease arising from polluted flood waters would be greatly reduced. Insecurity and worry among the residents would also be greatly reduced.

e. Total Annual Benefits - Total annual benefits, consisting of flood damage prevention benefits and redevelopment benefits, amount to $22,900 for the recommended project, exclusive of recreation benefits.


STAGE IN FEET REFERRED TO TYPICAL ICE-JAM FLOOD
+3
+2
+1
0
-1
-2
-3
STAGE OF TYPICAL
ICE-JAM FLOOD
STAGE-DAMAGE
CONNECTICUT RIVER BASIN
MOHAWK RIVER
COLEBROOK, NEW HAMPSHIRE
1963 PRICE LEVEL
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TOTAL RECURRING DAMAGE IN $1,000 UNITS



	RANGE "A"			RANGE "B" 1□"=$200			RANGE "C" 1□"=$6,000			TOTAL ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSS	BENEFIT
NATURAL	—	—	—	15.00	3,000	—	15.20	15,200	—	18,200	—
MODIFIED	—	—	—	15.00	—	3000	15.20	—	15,200	—	18,200

PLATE NO. B-2

APPENDIX C

HYDRAULIC DESIGN

PLATE

APPENDIX C

HYDRAULIC DESIGN

1. GENERAL

The spillway of the ice barrier dam will be designed to pass the standard project flood with three feet of freeboard on the non-overflow sections. The spillway will consist of a low ogee concrete weir with four ice breakers; a stilling basin with baffle blocks, and end sill; and a discharge channel. A gated conduit will be constructed integral with the spillway weir for draining the reservoir area. An orifice-type fishway, design details furnished by the New Hampshire Fish and Game Department, is provided adjacent to the right abutment of the spillway. The recreation pool will contain about 60 acre-feet of storage, equivalent to 0.02 inches of runoff from the 48 square mile drainage area. The general plan is shown on Plates No. 2 and 3 and details of the spillway and stilling basin are shown on Plate No. 5.

2. SPILLWAY LENGTH AND CREST ELEVATION

The net spillway length will be 215 feet and the corresponding surcharge depth will be 7 feet for the spillway design discharge of 15,000 cfs. The spillway crest elevation will be 1044.0 feet msl and top of the non-overflow sections will be elevation 1054.0 feet msl which will provide a freeboard of three feet.

3. DISCHARGE RATING CURVE

The discharge rating curve shown on Plate No. C-1 was determined by the conventional weir formula. The velocity of approach was considered to be negligible since the approach to the spillway will be excavated to elevation 1037 feet msl which will provide an approach depth of seven feet. The maximum tailwater with the project design discharge was estimated to be elevation 1042 feet msl. The coefficients of discharge shown on Plate C-1 were obtained from Hydraulic Design Chart 122-1/1 of Hydraulic Design Criteria were used in the conventional weir formula to obtain the discharge rating curve. Four concrete breakers will be constructed on the upstream face of the spillway weir in order to reduce the clear opening to about 40 feet and thus retard the discharge of sheet ice from the upstream pond. Since the breakers are set 11 feet upstream of the centerline of the weir, contraction was neglected and the full length was assumed to be effective.

4. CREST SHAPE

The low ogee crest of the overflow spillway was designed from Hydraulic Design Charts 111-1, 111-2 and 111-2/1 in the data book of Hydraulic Design Criteria. The maximum surcharge head of seven feet obtained by the standard project flood, was used in the formula to derive the parabolic equations for the upstream and downstream quadrants. Consideration was given to a lower design head in order to provide higher discharge coefficients, but it was concluded that high tailwater conditions during spillway discharges would probably obviate any increase in such coefficients. A short tangent section with a slope of 1 on 0.8 will be provided between the downstream quadrant and an apron curve with a radius of ten feet. A typical section of the spillway weir is shown on Plate No. 5.

5. TAILWATER RATING CURVE

There is no stage-discharge relationship available for the Mohawk River. An estimated tailwater rating curve was computed by conventional hydraulic formulas using topographic data and assuming a roughness coefficient of .035. A temporary staff gaging has been established in the vicinity of the stilling basin in order to verify the computed data.

6. SPILLWAY STILLING BASIN

a. General - The stilling basin was designed for the maximum project design flood discharge (15,000 cfs). It will be constructed with vertical walls and the floor elevation will be based upon the theoretical tailwater depth D_2 required to develop a hydraulic jump. As the reliability of the computed tailwater rating curve is somewhat questionable, it was decided not to apply any reduction to the theoretical D_2.

b. Stilling Basin Floor - The floor of the stilling basin will be at elevation 1029.5 feet msl which will provide the theoretical depth (D_2) of 12.5 feet for a discharge of 15,000 cfs. The estimated tailwater elevation at the end of the stilling basin was 1042 feet msl. The stilling basin was also checked for a discharge of 5000 cfs, the approximate bankfull capacity of the discharge channel is 6.5 feet. The top of bank or tailwater elevation is 1036 feet msl, resulting in a D_2 of 6.5 feet which is adequate for the formation of a hydraulic jump.

c. Length of Stilling Basin - The length of the stilling basin will be 48 feet, which is approximately equal to $4D_2$ as suggested in paragraph 2-23f of EM 1110-2-1062, Reservoir Outlet Structures, for stilling basins with baffle blocks and end sill.

d. Baffle Blocks and End Sill - Two rows of 2'x2' baffle blocks and end sill will be provided to insure that the hydraulic jump is not "swept out" of the stilling basin. The baffle blocks will be staggered and will be two feet high. The end sill will be two feet high with an elevation of 1031.5 feet msl.

7. SPILLWAY DISCHARGE CHANNEL

The spillway discharge channel, excavated in earth, will extend from the end of the stilling basin to the existing river channel, a distance of about 400 feet. The bottom width will converge from 233 feet below the stilling basin to 80 feet. The side slopes will be one on two and the channel bottom will have a slope of about 0.3 percent. The channel immediately below the stilling basin will be protected for 50 feet against erosion by heavy stones. A four foot wide low-flow channel will be provided along the right bank to insure an adequate amount of attraction water at the foot of the fishway.

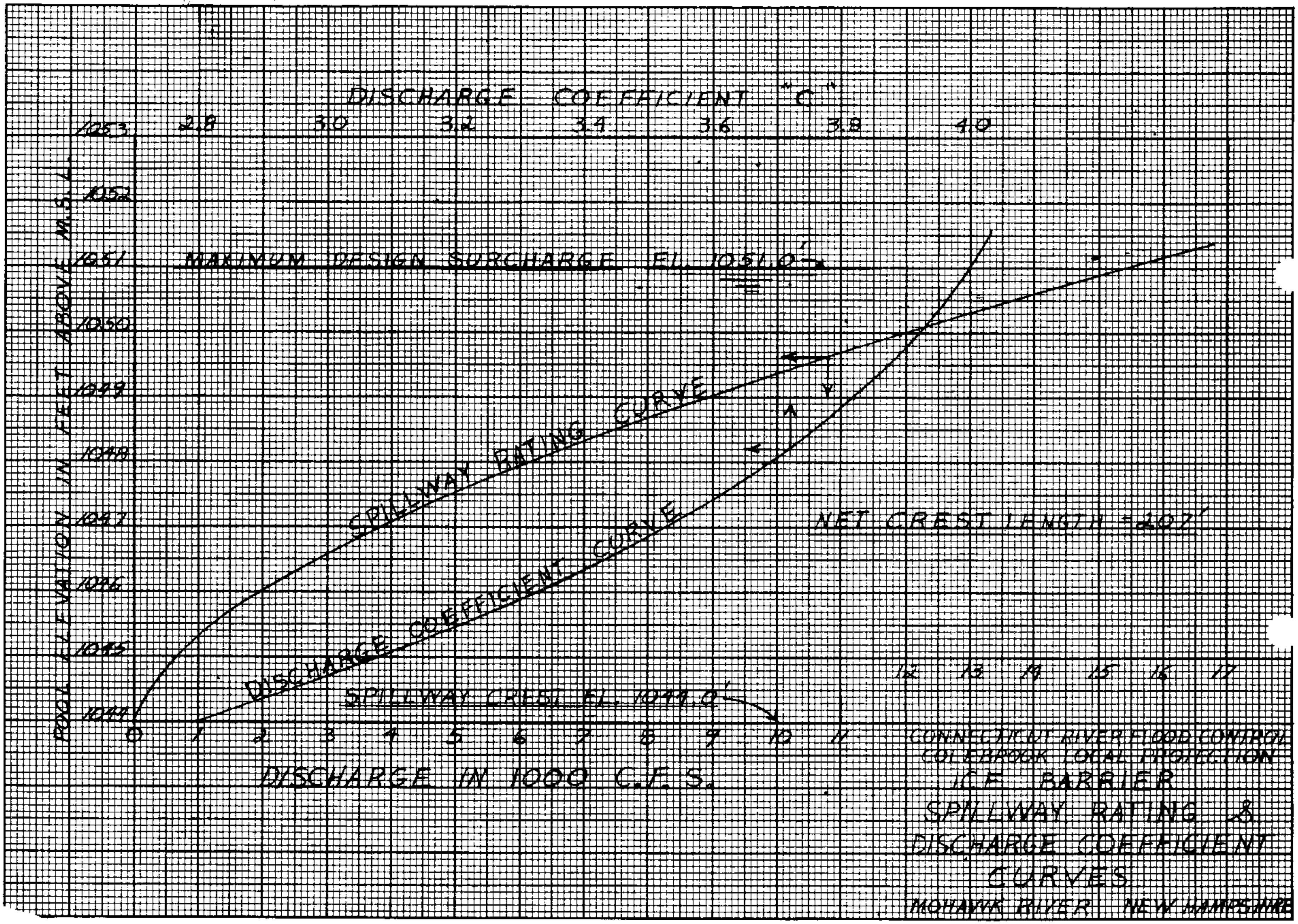

DISCHARGE COEFFICIENT "C"
2.8 3.0 3.2 3.4 3.6 3.8 4.0
POOL ELEVATION IN FEET ABOVE M.S.L.
1053
1052
1051
1050
1049
1048
1047
1046
1045
1044
MAXIMUM DESIGN SURCHARGE EL. 1051.0'
SPILLWAY RATING CURVE
DISCHARGE COEFFICIENT CURVE
NET CREST LENGTH = 207'
SPILLWAY CREST EL. 1044.0'
0 1 2 3 4 5 6 7 8 9 10 11
12 13 14 15 16 17
DISCHARGE IN 1000 C.F.S.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
ICE BARRIER
SPILLWAY RATING &
DISCHARGE COEFFICIENT
CURVES
MOHAWK RIVER NEW HAMPSHIRE

PLATE NO. C-1

U.S.Army Cold Regions Research
and Engineering Laboratory
Hanover, New Hampshire

December 1963

TECHNICAL MEMORANDUM

Control of Ice Jams at Colebrook, New Hampshire

1. The following appraisal was prepared upon invitation of U.S. Army Engineer Division, New England, Corps of Engineers. It is based upon two visits to the area (on 12 Sept 1962 and on 22 March 1963), an examination of detailed plans and length profiles, discussions with local inhabitants, as well as with representatives of the New England Division.

2. Although the main trouble area is just below the bridge A (inclosed figure) a complete survey was made along the entire river wherever access permitted. This was considered necessary for a better appraisal of possible control measures.

3. At point 1, where the Mohawk River enters the Connecticut River a sand bar is located which offers some resistance to the discharge of ice into the Connecticut River. The Connecticut River itself becomes ice free before the Mohawk River and does not offer a problem.

4. From 1 to 2 the shores are heavily overgrown with brush. The river is meandering which furthermore retards the discharge of ice.

5. A very sharp bend is located at point 3 which could cause frequent ice jams. There is evidence of an old river bed towards point 4.

6. Between 3 and 5 the river flows between steep banks. There is another sharp corner and change in cross section at point 6.

7. Between 6 and 7 the river shows evidence of past bulldozer work with widening of the channel which was performed in order to alleviate ice jam conditions. This stretch has partially open water during the winter, probably due to sewerage entering at point 7 into the Mohawk River. 8 is a small creek flowing through heavy underbrush. It frequently does not freeze during the winter.

8. The critical area for the formation of ice jams threatening the town is between 7 and A and especially at 9. The longitudinal slope of the river is negligible in the area and the bed is relatively wide and flat. During the early winter this stretch accumulates frozen frazil ice drifting from open stretches of the river above. This ice freezes to the bottom with a thickness of about 18" (22 March 1963) and about two feet of snow accumulates above it. There is very little water flowing during the winter which cuts a small channel.

9. During spring break-up ice coming from upriver strands in this area increasing thereby the roughness of the bed which could cause ice jams. Such a situation did not develop, however, in Spring 1963. The inspected evidence clearly points to this area as the main cause of trouble. Statistical material on the frequency of such occurrences is not available to the undersigned.

10. Starting from point 10 up to 11 the river is confined by concrete walls which in itself do not favor an orderly discharge of ice. It can be said that part of the trouble is due to man's past encroachment on the channel. During the winter the bed is heavily covered with frozen ice. The water runs in narrow channels which are open at some spots.

11. At point 12 there is a sharp bend in the river with a very steep right bank. This is a suitable location for a dam which should stretch towards 13. The area marked with B is a low meadow ideally suited for an ice accumulation area during spring break-up.

12. There are concrete blocks placed in the river bed at 14. The purpose of these blocks was to cut pieces of ice before they go the difficult section in town. This was supposed to alleviate the ice jam situation but was not particularly effective.

13. The entire drainage area of the Mohawk is 57 square miles most of which is located below a reservoir at the Balsams resort near the Dixville ~~Motel~~ Notch. The stretch of the river up to this reservoir has the characteristics of a rapidly flowing stony creek. Such rapid water courses are known to create large amounts of frazil ice. An inspection during the winter revealed numerous open stretches with rapid flow and much ice frozen to the bottom and stones. There is no evidence that large chunks or plates of ice could form during the winter. More likely it is a debris of smaller pieces with soft frazil ice, an ideal mixture for clogging and ice jams.

14. According to

USA CRREL, Technical Note, 26 Feb 1961,
"Criteria for ice jamming", by A. Assur

the "ice jamming number"

$$P_1 = \frac{Qi \quad N^{1/6}}{h\, b\, \wp c\, (H-h)^{2/3}\, S^{1/2}} \tag{1}$$

determines the beginning of an ice jam and the "ice packing number"

$$P_2 = \frac{Qi \quad N^{1/6}}{G\, b\, H^{2/3}\, S^{1/2}} \tag{2}$$

determines the formation of an ice jam

Qi - discharge of ice
N = n^6 a friction height
n ~~M~~ - Manning's friction coefficient
G = $\gamma(1-\gamma)^{2/3} \wp c$
$\gamma = h/H$
h - ice thickness
H - depth of water
$\wp$ - ratio of surface to mean velocity of water
c - coefficient in Manning's formula
b - width of channel
S - Slope

15. Equation (1) and (2) were developed from simple hydraulic considerations. Formula (2) applies for this case sine (1) deals with a river having considerable discharge with ice floating relatively free until jamming starts. A qualitative discussion of (2) may be in order.

16. A high P2 number will lead to ice packing and clogging in the channel. This is proportional to the discharge of ice, which in turn is proportional to its thickness and the intensity of break-up. The nature of ice freezing in the Mohawk is such that large amounts of ice are being created in the form of frazil ice in open water stretches as well as by overflow. Much less ice and less troublesome ice forms in quiet river courses. The only limit to ice formation is the small winter discharge of water. The steep slopes in the basin and large amounts of snow may cause rapid thawing and runoff in some winters leading to a large Q_i . The friction characterized by N is

high, especially between 7 and A with large masses of ice adfrozen to the bottom. With h approaching H, G = $\gamma(1-\gamma)^{2/3}$ is small leading to a large p2. The water depth H is small producing the same effect. The relatively large width b is and advantage taken by itself. The most significant factor in the critical area 9 is the small slope S leading to a large ice packing number p_2.

17. The described factors point therefore towards an undesirable combination of circumstances influencing the formation of ice jams in the area 9. The question now arises what corrective measures could be taken. We will not discuss here economic factors, whether or not a certain measure would be economically justified. We will rather concentrate at this point on the question whether or not it will be effective. There are a number of measures which could be taken alleviating the situation slightly and other, more expensive measures which will prevent ice jams effectively.

18. The meandering section 1 to 2 and the sharp bend at 3 are nuisances which could be eliminated by cutting a channel directly towards point 4 into the Connecticut River. This would facilitate an orderly discharge into the Connecticut, but would not alleviate the situation in Colebrook itself. There are no structures affected by ice jams at the mouth of the Mohawk River.

19. Some deepening and straighting of the channel could be done between 6 and 7 as had been tried before. This would hardly be effective.

20. Channel deepening may be accomplished between 7 and 9 forming a narrow trapezoidal channel in the gravel bed. This may provide temporary relief of questionable nature since the channel would fill with gravel again in a year or two.

21. By far the most effective solution would be an earth dam, as mentioned above, approximately between points 12 and 13 with a concrete spillway designed in such a way that the spring flood waters would be discharged through the opening but the ice retained behind in a flooded area.

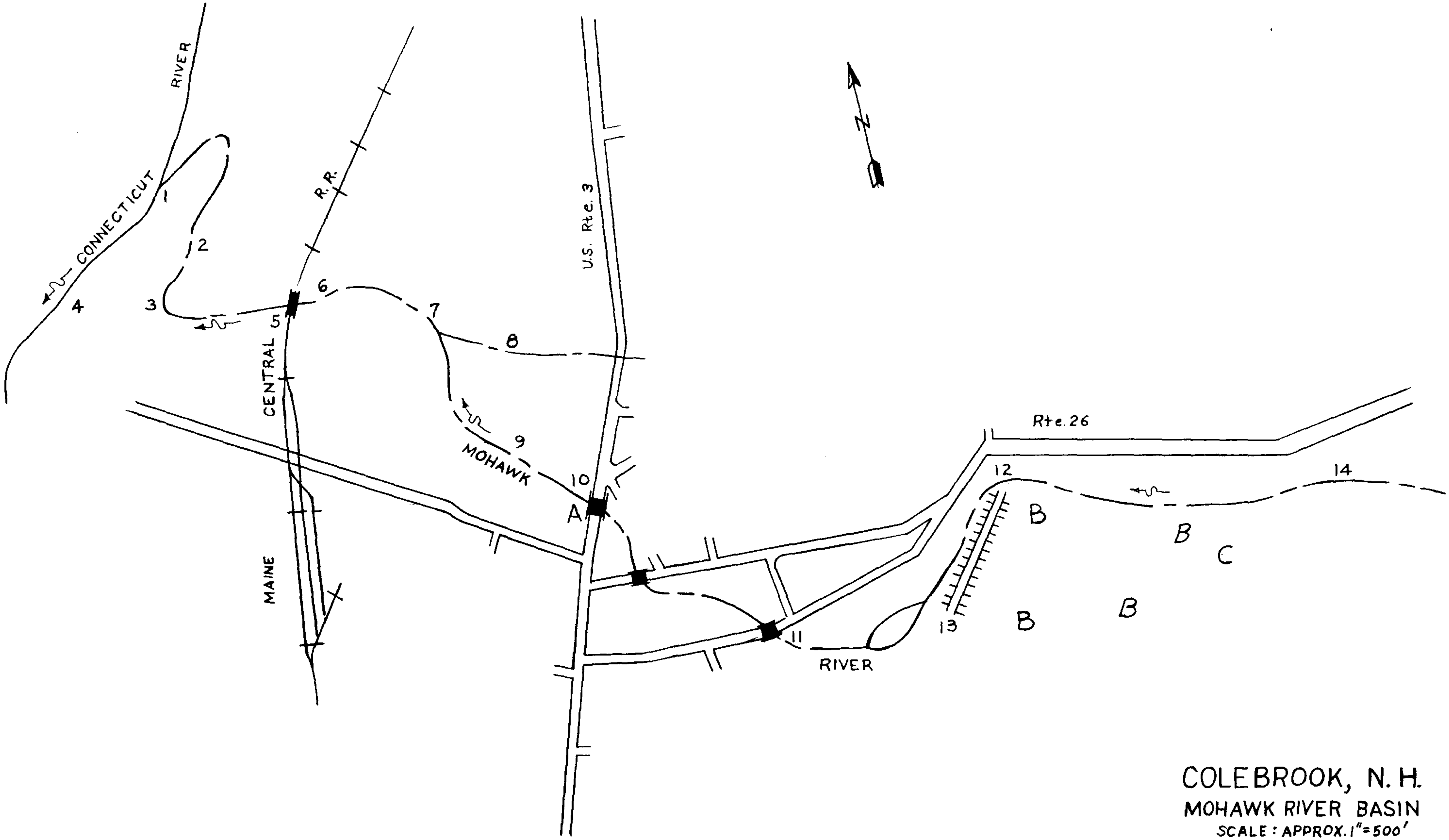
22. It is very important to flood the meadow in the area B. This creates a wide reservoir for the accumulation and gradual wastage of ice. The dam would lose a considerable portion of its effectiveness if the meadow would not be flooded. The area under question has been studied on survey sheets and by inspection on foot. It is highly suitable for the suggested solution.

23. Due care should be taken in cutting down some elevated areas around C and also along the present left bank of the river in the area B. Failure to do it would eventually result in wooded islands which would cause other ice jams especially in the area C.

24. The resulting lake could be developed as a recreational area providing additional benefits for the area.

A. ASSUR
Scientific Advisor

G. Frankenstein
Civil Engineer



COLEBROOK, N. H.
MOHAWK RIVER BASIN
SCALE : APPROX. 1" = 500'

APPENDIX D

GEOLOGY, EMBANKMENT AND FOUNDATIONS, AND CONCRETE MATERIALS

PLATES

APPENDIX D

A. GEOLOGY

1. SURFICIAL AND SUBSURFACE INVESTIGATIONS

Reconnaissance was done at and in the vicinity of the site in November 1962 to assist in planning required foundation explorations and to determine the availability of borrow materials. Subsurface explorations consisting of seven borings and nine test pits were completed to investigate foundation conditions. The borings and two of the test pits were located along the base line as shown on Plan and Record of Exploration, Plate D-1. Seven test pits were completed along the valley bottom to determine the character of materials which would be encountered in required excavations. A test pit and trench were excavated in a selected area on the hillside above the left abutment to obtain samples of the local till for tests to determine its suitability for use in the embankment. The exposed face of an old borrow pit located on New Hampshire Route 3 approximately one-half mile north of the site was also sampled for the same purpose. The location of all explorations and description of all materials encountered is shown on Plan and Record of Explorations, Plate D-1; Project Plan, Plate 1; and Dam and Reservoir Plates 2 and 3 of the main report.

2. FOUNDATION CONDITIONS

The explorations indicate that bedrock is deeply buried throughout the site. The overburden, both in the terraces which form the abutments of the dam and in the valley bottom, consists mainly of glacial outwash underlain at varying depths by till. In the valley bottom the outwash is partly covered by recent alluvium. The alluvium and the outwash are roughly stratified and lensed and consist of sands and gravels with varying amounts of silt. Locally and generally at the surface, scattered thin beds of sandy silt occur.

There is little apparent difference between much of the outwash and the underlying till. The outwash appears in large part to be a poorly sorted, reworked till. Similarly the till is not typical of the local till but appears to be discontinuous deposits of unsorted material dropped in place from buried ice blocks in the outwash. The till ranges generally in gradation from silty, sandy gravel to silty, gravelly sand, all with cobbles and occasional boulders.

As shown in log-profile, Plate D-1, rotted wood encountered in boring FD-5 indicates that the alluvial material in the valley bottom occurs to depths up to 10 feet. Till was encountered in the left abutment at a depth of 16 feet and locally at scattered locations in the valley bottom at depths ranging from 8 to 20 feet. Wherever encountered, however, zones of outwash occurred in the till. Throughout most of the foundation in the valley bottom and right abutment, outwash occurs to depths of more than 40 feet.

3. SUBSURFACE WATER

Observations of water levels taken in borings during exploration indicate that subsurface water levels throughout the foundation area are essentially at river level.

4. AVAILABILITY OF CONSTRUCTION MATERIALS

a. Random Material - Suitable material from required channel and foundation excavations will be utilized in the embankment. The material from these excavations consists of recent river deposits and outwash which occur in the valley bottom. Beneath 1 to 3 feet of silty, sandy topsoil, these materials are composed mainly of roughly stratified and lensed, silty, sandy gravel with cobbles and scattered boulders. Locally beds of silty sand and sandy silt occur generally overlying but also interbedded with the gravels. The level of subsurface water in the valley is relatively high and it must be anticipated that excavations will encounter water at depths of 4 to 6 feet.

b. Impervious Materials - Borrow material required for construction of impervious sections of the embankment may be obtained from local till deposits adjacent to the site. Explorations BTT-1 and BT-2 located on the hillside immediatley above the terrace on the left abutment indicate that the area is underlain by till and that a large quantity of suitable material is available for use in impervious sections of the embankment. The till consists mainly of gravelly, silty sand and silty sandy gravel with cobbles and boulders. Similar material was also sampled in an old borrow pit located on New Hampshire Route 3 approximately one-half mile north of the site as shown on Plate 1. The gradation of the till in these two areas is shown by grain size on Plate D-3.

c. Pervious Material - Material for gravel bedding and road gravel can be obtained from local sources. Selective operations or processing would be required, however, to produce suitable material from these deposits. Both filter stone and filter sand material required under the spillway apron could also be obtained by processing and crushing material from the coarser phases in some of the local deposits. Adjacent to the railroad west of the town there is a large deposit of gravelly sand which is being operated to produce aggregate for concrete. The deposit is mainly fine to coarse sand but there are minor gravel beds in the deposit with a small proportion of material up to about four-inch size. An abandoned pit in a large deposit west of Main Street and north of the Mohawk River although sloughed, appears to contain a higher proportion of gravel than is available in the operating pit near the railroad. Several other deposits are being operated approximately one mile south of Colebrook in the vicinity of the Oblate Monastery and deposits of pervious materials also occur in the vicinity of Stewartstown Hollow School approximately five miles north of the site. Large commercial producers of processed sand and gravel are located near Littleton, New Hampshire and St. Johnsbury, Vermont, approximately 60 miles from the site.

d. Rock Channel Protection and Rock Slope Protection Material Approximately 5300 cubic yards of rock are required for rock slope protection and rock channel protection. The bedrocks in the vicinity of Colebrook consists of slate and phyllite which are relatively soft, weak and would break in quarrying to produce very thin, flat and elongate fragments. Excellent rock is available, however, at an abandoned quarry on Meriden Hill approximately 10 miles south of Colebrook. The rock is pink granite popularly called "rose granite". This rock is relatively hard, strong and massive so that quarried fragment shapes would be blocky and good gradation could be obtained.

e. Concrete Aggregates - It is estimated that approximately 6100 yards of concrete will be required for construction of the spillway weir, walls and apron. Prior investigations on aggregate materials made several years ago in connection with other flood control projects indicate that acceptable materials are available within approximately 60 miles of the site. Complete data on re-evaluation of previously investigated materials and on materials from new sources closer to the site are presented in paragraph C, Concrete Materials.

B. FOUNDATIONS AND EMBANKMENT

5. CHARACTERISTICS OF FOUNDATION MATERIALS

a. Description and Distribution of Materials - An engineering log profile indicating the description of materials at the damsite is shown on Plate No. D-2. The foundation areas of the dam embankment, spillway structure and abutment walls were explored to depths of from 40 to 50 feet without encountering bedrock. These foundation areas are capped with topsoil and forest debris to an average depth of 18 inches except that a surficial layer of cobbles covers the present riverbed. The overburden, in general, contains numerous cobbles and boulders and some weathered cobbles and gravel. Recent river deposits of erratically stratified loose to moderately compact gravels and sands with numerous silty phases and occasional pockets and lenses of sandy silts and organic materials cover the area generally to a depth of about 4 feet. These recent river deposits are underlain by deposits of glacial outwash and sandy glacial till. The materials in these lower deposits are similar with respect to gradation and the boundary between the outwash and till deposits is difficult to establish. The materials in these lower deposits consist principally of brown, roughly stratified to unstratified, loose to moderately compact, non-plastic, gravelly silty sands, silty sands and silty sandy gravels with occasional lenses or pockets of gray moderately compact sandy silt. Gravel contents of these materials vary widely but are generally over 10 percent. Silt contents range from 10 to 30 percent of the component passing the No. 4 U. S. Standard Sieve. As a general rule, the materials having the lower silt contents occur in the upper 10 feet of the overburden. Subsurface water levels at the time the foundation explorations were made, ranged from 3 to 15 feet below ground surface and generally correspond with the river level. Selected laboratory test data are shown on Plate No. D-3 and a summary of laboratory test results is shown on Plates Nos. D-5 and D-6.

b. Shear Strengths and Permeabilities - Shear and permeability tests were not performed on samples of the foundation soils. On the basis of visual examination of the samples and their grain size distribution curves, the exploration logs, and experience with similar materials, the following shear strength parameters and ranges of coefficients of vertical permeability are estimated for the various types of foundation materials. It is estimated that the coefficients of horizontal permeability are generally about 16 times the vertical.

Materials	Shear Strength ($\emptyset$, degrees)	(c, tsf)	Permeability (K_v, x 10^{-4} cm/sec)
Recent River Deposits	25	0	10 - 75 Avg. 40
Glacial Outwash Deposits	30	0	0.1- 10 Avg. 0.5
Glacial Till Deposits	30	0	0.1- 10 Avg. 0.5

c. Consolidation Characteristics - Consolidation tests were not performed on samples of foundation materials for this project. Except for the sandy silts in the river deposit, these materials exhibit very low compressibilities. The sandy silts, while relatively compressible, occur generally in thin lenses and pockets and any settlement due to their consolidation would be of minor magnitude.

6. DESIGN OF EMBANKMENTS

a. Criteria - Current design criteria as set forth in the pertinent sections of the Engineering Regulations for Civil Works Construction, No. 1110-2-2300 "Earth Embankments" and regulations and bulletins referred to therein has been followed in the design of the embankments for this project.

b. Selection of Embankment Sections - Typical embankment sections for this project are shown on Plate No. 4 of the main report. The embankment sections selected for the dam have been developed from investigations and studies of foundation conditions and of the characteristics of available construction materials and foundation soils. The selected sections are of both the zoned and homogeneous rolled earth fill types with upstream blankets and small downstream rock toes. The embankment averages about 19 feet in height. Side slopes of 1 vertical on 4 horizontal upstream and 1 vertical on 3 horizontal downstream have been adopted except for that portion of the embankment in the vicinity of the spillway where the upstream slope will be warped from 1 vertical on 4 horizontal to 1 vertical on 2 horizontal to avoid encroachment on the spillway channel. Relatively flat side slopes were selected for the embankment sections so as to provide a structure in which materials from the required excavations (which are quite variable with respect to shear strength and permeability characteristics) could be used with a minimum of selection and waste. In addition, these relatively flat slopes also offer the advantage of reducing the amount of rock slope protection which will have to be contractor furnished from offsite sources.

All earth fill slopes will be topsoiled and seeded except in the areas of the warped slopes at the spillway and portions of the upstream slope below the level of the conservation pool, which areas will be provided with rock slope protection. The homogeneous earth fill section and contiguous reservoir side blanket consists of compacted impervious fill. The zoned earth fill section consists of a downstream compacted random fill section and an upstream compacted impervious fill section and contiguous reservoir side blanket.

c. Characteristics of Embankment Fill Materials - Random fill materials for the dam embankment will be obtained from the required excavations for the project and will consist principally of sandy gravels and silty sands. Silt contents of these materials generally range between 5 and 30 percent of the component passing the No. 4 U. S. Standard Sieve. It is estimated that the random fill material in place will have a coefficient of permeability of from 5x10-4 to 50x10-4 cm/sec and will develop an angle of internal friction of at least 25 degrees. Impervious fill materials will be furnished by the contractor from approved sources. Investigations of potential sources in the vicinity of the project indicate that well graded, non-plastic glacial till, having a gravel content of 25 percent or less and silt content of at least 20 percent can be obtained within 5 miles of the project. It is estimated that the impervious fill material in place will have a coefficient of permeability of less than about 1x10-4 cm/sec and will develop an angle of internal friction of at least 30 degrees. Selected laboratory test data for the random and impervious fill material are shown on Plate No. D-3 and a summary of laboratory test results is shown on Plates Nos. D-5 and D-6. Gravel bedding material for use in the embankment and elsewhere on the project will consist of reasonably well graded bankrun sandy gravels or gravelly sands furnished by the contractor from approved sources. Of the portion of the material passing the 3-inch U. S. Standard Sieve, from 25 to 60 percent shall pass the No. 4 U. S. Standard Sieve and of the component passing the No. 4 U. S. Standard Sieve no more than 15 percent shall pass the No. 200 U. S. Standard Sieve.

d. Control of Seepage - Seepage through the dam embankment will be controlled by the arrangement and differences in permeabilities of the earth fill zones and by the downstream gravel bedding and the rock fill. Seepage through the embankment foundation will be controlled by the upstream blanket and by the toe drain beneath the downstream rock toe. The average gradient for seepage through the embankment foundation will be in the order of 5 percent at maximum differential hydraulic head. The quantities of seepage through the dam embankment and foundation will not be significant.

e. Slope Stability - Slopes of 1 vertical on 4 horizontal upstream and 1 vertical on 3 horizontal downstream are considered to be adequately safe against shear failure because of the relatively low embankment heights and hydraulic heads and because of the relatively high shear strengths of the embankment and foundation materials. The 1 one 2 upstream slopes in the short reaches in the vicinity of the spillway weir are considered to be adequately safe against shear failure because in addition to the relatively low embankment heights and hydraulic heads and the strength of the foundation and embankment materials, these slopes will be covered with rock slope protection and gravel bedding layers.

f. Settlements - It is anticipated that, in general, settlement of the embankment foundation and the embankment materials will not be significant and will occur during construction.

g. Slope Protection - Since the upstream slope of the dam embankment is relatively flat and since waves of significant heights are not anticipated, the major portion of these slopes above the elevation of the permanent pool will be topsoiled and seeded to provide protection against erosion. The upstream slope below the permanent pool elevation will be covered with a 2 foot layer of rock slope protection over 12 inches of gravel bedding to provide protection against the effects of continuous exposure to minor wave or eddying action, and ice conditions. In order to improve the stability of the upstream dam embankment slope in the vicinity of the spillway weir and because spillway velocities in this area may be as high as 10 ft/sec, a 2 foot layer of rock slope protection over 2 feet of gravel bedding is provided. Rock slope protection material will consist of crusher-run quarry stone that averages 30 and 50 pounds in weight with a maximum size of 150 pounds. The downstream slope of the dam above the rock toe will be topsoiled and seeded to prevent erosion.

h. *Construction Considerations*

(1) Removal of Unsuitable Foundation Materials - Stripping of the embankment foundations will consist of the removal of topsoil and will average about 18 inches in depth. In addition, the layer of cobbles will be removed from the bottom of the Mohawk River in order to prevent the formation of detrimental seepage paths in the base of the embankment.

(2) Spoil Area - Spoil material will be disposed of in the designated areas downstream of the dam.

7. DESIGN OF SPILLWAY DISCHARGE CHANNEL

a. Slope Stability - Explorations to determine the character of the overburden materials along the selected alignment of the spillway discharge channel were not made. Site reconnaissance, general geology of the area, explorations made to determine overburden conditions for a channel alignment to the west of selected location, and explorations made to determine the foundation conditions for the dam embankment and spillway structure all indicate that the overburden materials are essentially the same as described in Paragraph 1b above. Based on previous experience with similar materials at the other sites and due to the fact that the maximum depth of the spillway discharge channel will be in the order of 6 feet, the selected side slopes of 1 vertical on 2 horizontal are considered to be adequate.

b. Channel Protection - Since velocities along the downstream edge of the stilling basin are estimated to be as high as 10 ft/sec and turbulent flow is expected in this area, the bottom and side slopes of the spillway discharge channel will be protected with a 2 foot layer of rock channel protection over 12 inches of gravel bedding for a distance of 50 feet downstream of the stilling basin. Rock channel protection will consist of quarry stone that average between 80 and 100 pounds in weight, with a maximum and minimum size of 175 and 30 pounds, respectively. The curve suggested by the U.S. Bureau of Reclamation shown on Hydraulic Design Chart 712-1 [1] in the data book of "Hydraulic Design Criteria" was used as a guide[1] in selecting the stone size for this area. Gravel bedding will conform to similar materials described in Paragraph 2c above.

8. FOUNDATIONS FOR CONCRETE STRUCTURES

a. General - The foundation conditions for the concrete spillway structure and abutment walls are discussed in Paragraph 1, above. Foundation grades for these structures have been established at such elevations so as to provide gravelly sand foundations. It is estimated that these materials will have a bearing value in excess of 3 tons per square foot.

b. Control of Seepage

(1) Spillway Structure - Seepage through the foundation of the spillway structure will be controlled by an upstream compacted impervious fill blanket, a downstream concrete apron with weepholes and underlying drainage blanket, and a toe drain. Studies made of other methods of seepage control, such as sheet pile cutoffs, or increased base widths showed that they would be either impracticable

or uneconomical. Flow net analyses showed that the selected system of seepage control with an 80-foot upstream blanket would provide adequate relief of uplift pressures and satisfactory exit gradients and that the quantity of seepage passing through the foundation of the spillway structure would not be significant. This flow net analyses is shown on Plate No. D-4. However, due to the variable and semi-pervious to pervious nature of the foundation and in order to guarantee that a reservoir pool can be maintained at Elevation 1044, an essential requirement of the proposed ice control barrier, the length of the blanket was increased by 100 feet. The drainage blanket beneath the concrete apron will consist of 12 inches of filter stone overlying 12 inches of filter sand. The gradations of the filter stone and filter sand will be similar to those of 3/4-inch to No. 4 coarse concrete aggregate, and fine concrete aggregate, respectively.

(2) Spillway Abutment Wingwalls - Seepage along and around the spillway abutment wingwalls will be controlled by a compacted impervious fill wrap-around section. This section will provide a horizontal creep ratio greater than 8 for both the normal operating and flood conditions.

c. Construction Considerations - All concrete and fill and backfill materials associated with the spillway structure and abutment walls will be required to be placed in the dry.

C. CONCRETE MATERIALS

9. CONCRETE AGGREGATES

Approximately 6100 cubic yards of concrete will be required for construction of spillway weir and walls. In view of the small quantity of concrete required, aggregate investigation has been confined to established commercial sources. A field reconnaissance was conducted by an engineer-geologist team to determine possible sources of supply. Five commercial sources of materials are available.

a. Gray Construction Company - This pit with a Cedarapids portable dry crushing and screening plant is located in Colebrook approximately one mile from the project site. A field petrographic analysis indicates the bank run material is approximately 40 percent quartz and quartz varieties, 30 percent schist and phyllite, 15 percent basics and volcanics, 5 percent granitic and 10 percent miscellaneous with a large percentage moderately weathered. Grading and soundness tests were performed on samples of coarse aggregate. The grading ranges from 2-1/2 inches to 3/8-inch and soundness test result is 40 percent loss after five cycles in magnesium sulfate. The grading of the fine aggregate was satisfactory except for excess amount of material passing No. 200 sieve due to sand being processed dry and a test result of Figure 1 minus was obtained in the organic color test. Based on the above information this source is presently not in a position to supply aggregate and additional investigational testing is not being considered.

b. Carpenter Redi-Mix Company - This company operates one quarry and two gravel pits for use in transit mixed concrete with this plant being located in St. Johnsbury, Vermont. One pit is located in Gilman Village, Vermont, approximately a 35-mile haul distance to the project site. The other pit and the quarry are located in Island Pond, Vermont approximately a 32-mile haul distance from the project site. One portable crushing and screening plant is used to process material from both pits and the quarry. Because of the haul distances and the nature of the processing operation, investigational testing is not being considered.

c. Littleton Sand and Gravel Company - This pit is located in Littleton, New Hampshire approximately a 58-mile haul distance to the project site. Because of the haul distance investigational testing is not being considered.

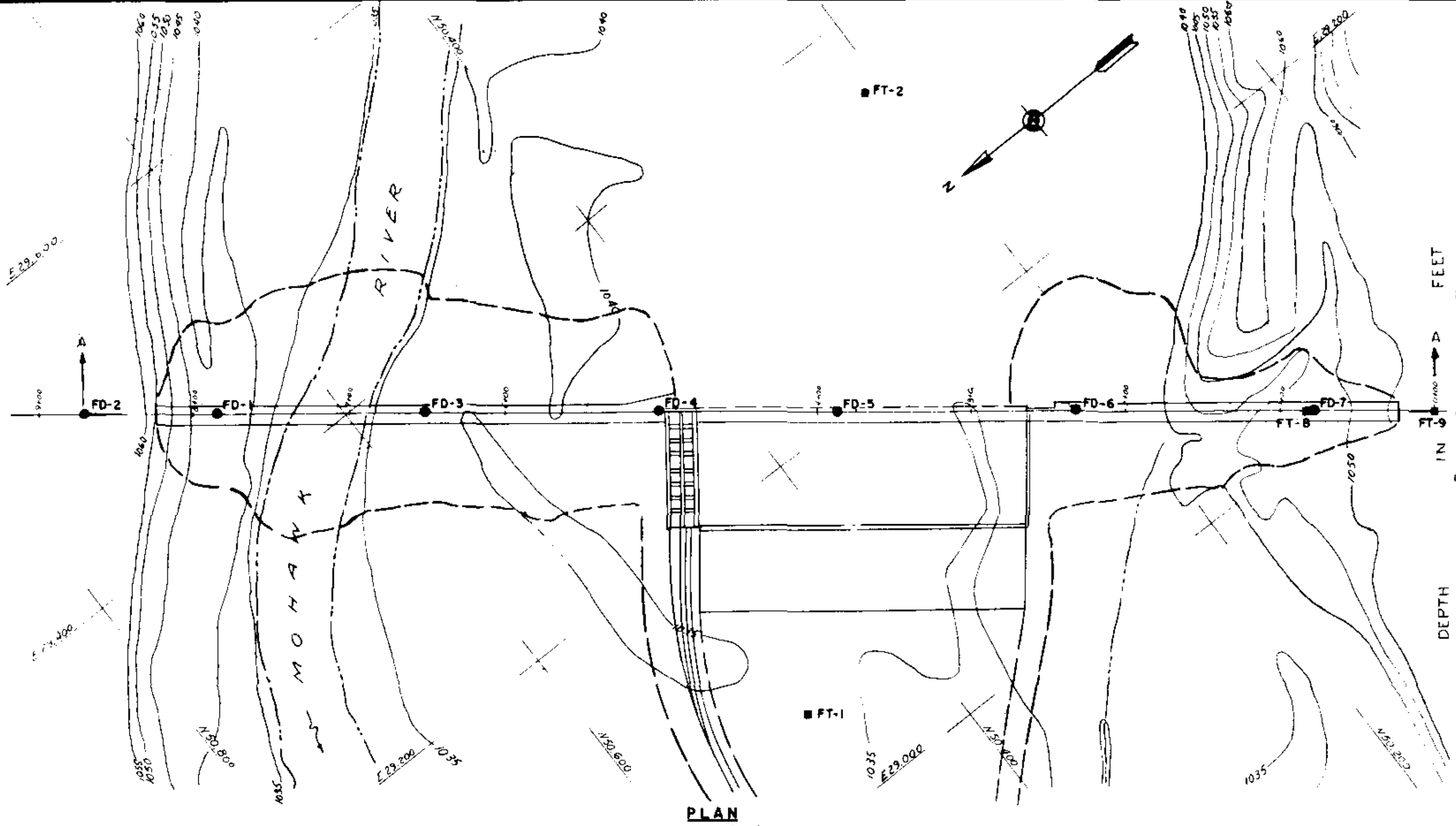
d. Lessard Sand and Gravel Company - This pit is located in Gorham, New Hampshire approximately a 58-mile haul distance to the project site. Data on this source are reported in Volume 5 of Technical Memorandum No. 6-370 "Concrete Aggregate in Continental United States". Index No. 2, Latitude 44°N and Longitude 71°W. A field petrographic analysis indicates the material is similar to that which has previously been tested. Quoted plant prices are $2.00 per ton for gravel and $1.20 per ton for concrete sand, and delivered prices of $6.20 per ton for gravel and $5.40 per ton for concrete sand.

e. Caledonia Sand and Gravel Company - This pit is located in Waterford, Vermont, approximately a 70-mile haul distance to the project site. Data on this source are reported in Volume 5 of Technical Memorandum No. 6-370 "Concrete Aggregate in the Continental United States". Index No. 1, Latitude 44°N and Longitude 71°W. A field petrographic analysis indicates the material is similar to that which has previously been tested. Quoted plant prices are $1.80 per ton for gravel and $0.80 per ton for concrete sand, and delivered prices of $6.70 per ton for gravel and $5.70 per ton for concrete sand.

It is recommended fine and coarse aggregate from Lessard Sand and Gravel Company and Caledonia Sand and Gravel Company be approved.

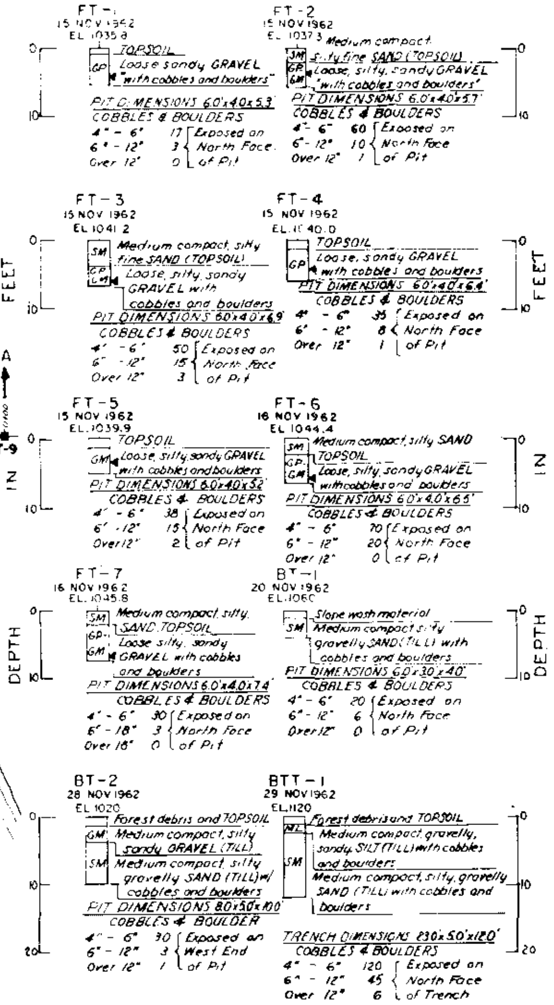
CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE 1" = 40'



LEGEND FOR GRAPHIC LOGS

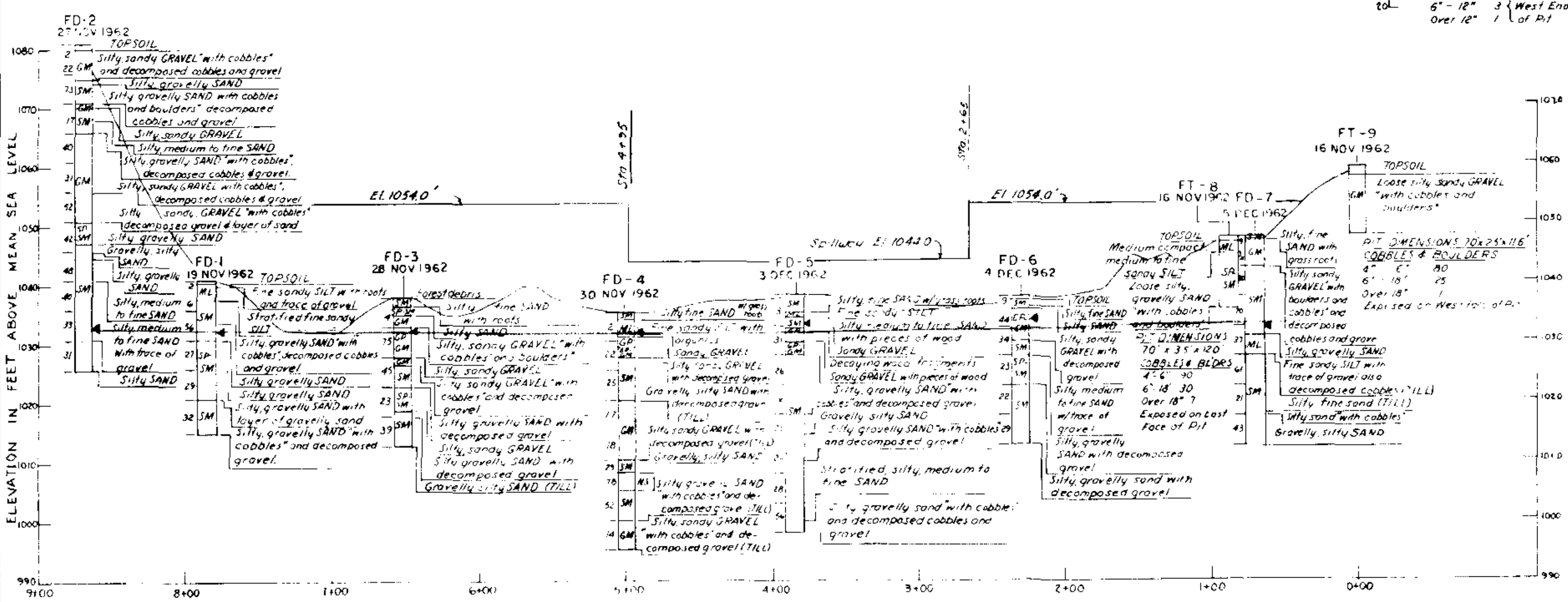
FD	Foundation Test Boring
FT	Foundation Test Pit
BT	Borrow Test Pit
BTT	Borrow Test Trench
5 DEC 1962	Date exploration completed
EL. 1035.0	Elevation of ground surface during time of exploration
	Subsurface water level in boring at time of exploration
SM	Group letter symbol according to Unified Soil Classification System
NS	Not Sampled. Hole advanced by Core-drilling, blasting and/or wash boring, due to operational difficulty
40	Blows per foot of penetration considered most representative for each sample drive, using a 300 pound hammer with a free fall of about 18" on a 2" I.D. or 2½" O.D. or 2⅝" I.D. a 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.

Water levels recorded during surface explorations seldom correspond with natural levels of free ground water except in extensive and thick deposits of sands and gravels which are sufficiently pervious to permit rapid stabilization of water levels in the exploratory hole. Absence of subsurface water level in the graphic log of of any exploration is not necessarily to be construed that ground water will not be encountered in excavation at that location.

While the borings are representative of subsurface conditions of their respective locations and for their respective vertical reaches, local variations characteristic of the overburden and rocks of this region are anticipated and if encountered, such variations will not be considered as differing "materially" from represented conditions within the purview of Article 4 of the Contract.

LEGEND

- FD Foundation Test Boring
- FT Foundation Test Pit
- BT Borrow Test Pit
- BTT Borrow Test Trench
- Location and direction of view at Log-Profile



LOG-PROFILE A-A

(LOOKING UPSTREAM)

NOTES

Elevations refer to Mean Sea Level Datum.
Contour interval is 5 Feet
Assumed Local Plane Coordinate Grid
For locations of FT-3 through FT-7, see PLATE 2. and PLATE 3.
For locations of BT-1, BT-2 and BTT-1 see PLATE 1.

GRAPHIC SCALE

1" = 40'   40'   0   40'   80'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DES. BY H.A.V. | DR. BY R.A.W. | CK. BY R.C.G.

CONNECTICUT RIVER FLOOD CONTROL

MOHAWK RIVER BASIN

COLEBROOK, N.H.

PLAN AND RECORD OF EXPLORATIONS

MOHAWK RIVER — NEW HAMPSHIRE

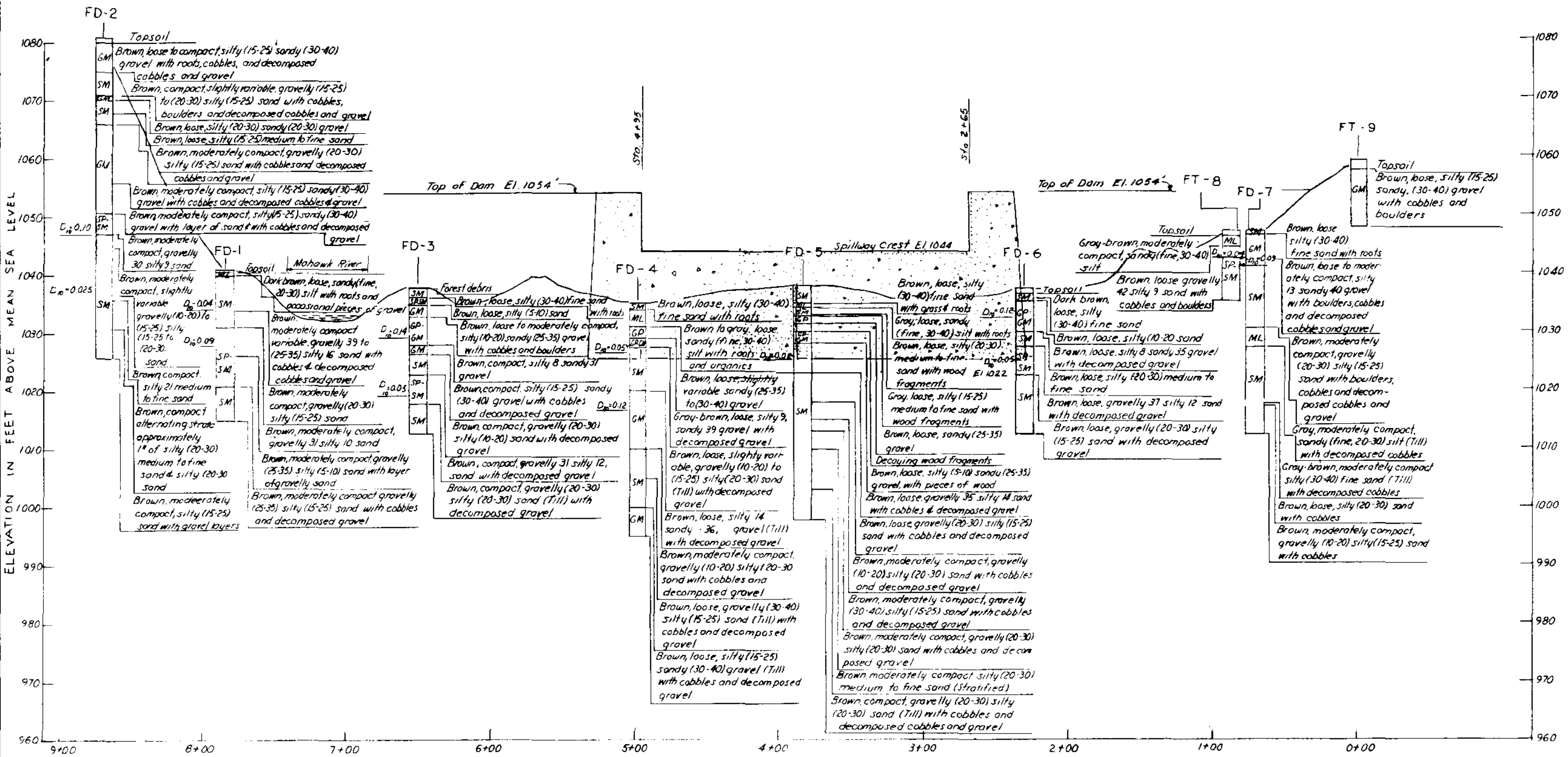
APPROVED — DATE

SCALE | SPEC. NO CIV. ENG.-19-016

DRAWING NUMBER

SHEET

PLATE NO. 8-1



ENGINEERING LOG PROFILE ALONG ¢ DAM

(LOOKING UPSTREAM)

NOTES

For Location of Explorations, see Plate No. D-1

LEGEND FOR ENGINEERING LOGS

D_{10}	Effective grain size in millimeters
26	A single numeral following a soil component in the description of a soil represents the percentage, by weight, of that component in the soil as determined by a mechanical analysis.
(10-20)	A range of numbers in parentheses following a soil component in the description of a soil, represents the estimated limits between which lies the percentage, by weight, of that component in the soil determined by visual inspection.
SM	Soil Symbol, Unified Soil Classification System

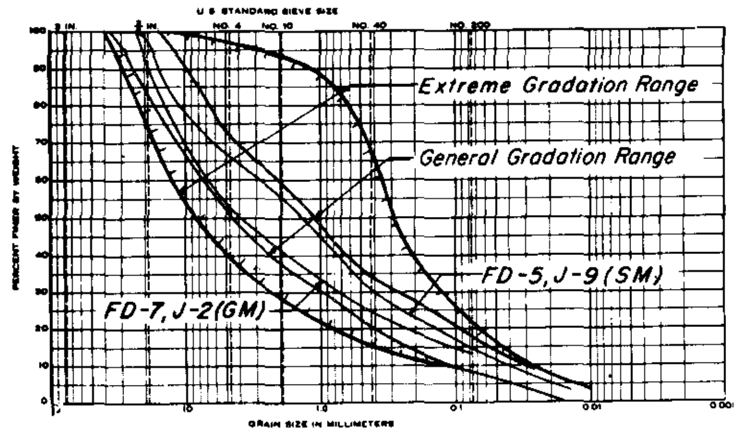
CONNECTICUT RIVER FLOOD CONTROL

MOHAWK RIVER BASIN

COLEBROOK, N. H.

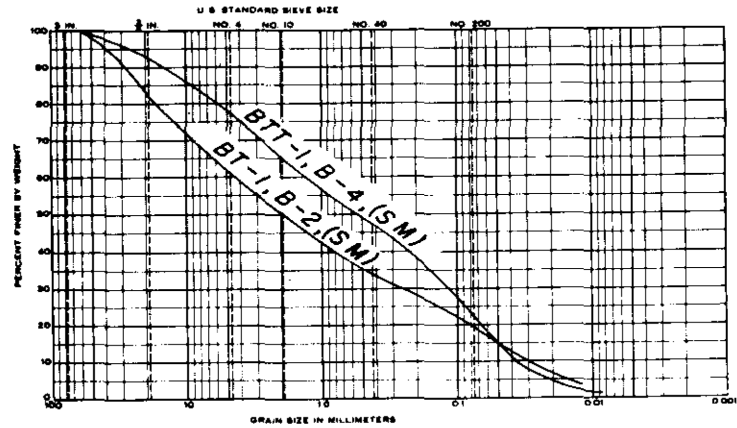
ENGINEERING LOG PROFILE

MOHAWK RIVER NEW HAMPSHIRE

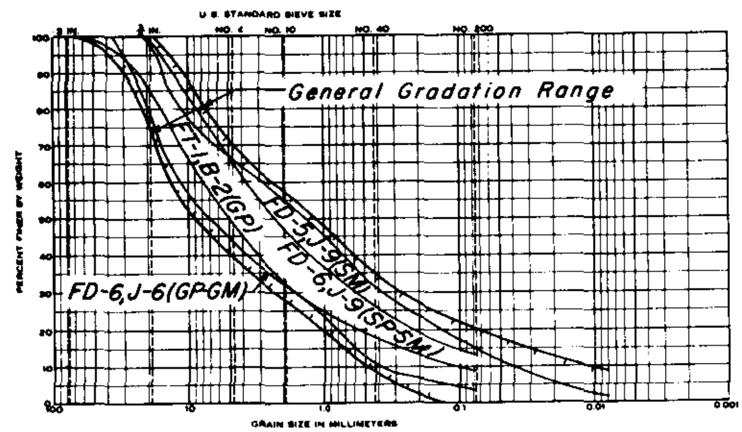


FOUNDATION MATERIAL

EXCLUSIVE OF SURFICIAL DEPOSITS
OF SANDY SILT AND SILTY SANDS



IMPERVIOUS EMBANKMENT MATERIAL

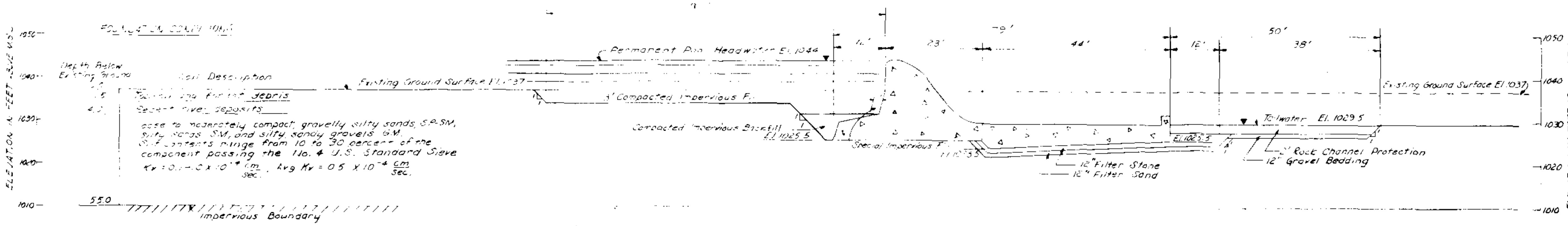


RANDOM EMBANKMENT MATERIAL

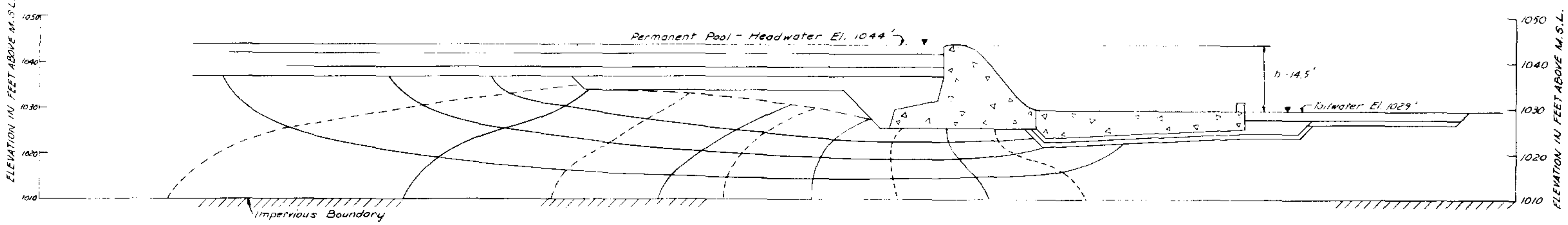
CONNECTICUT RIVER FLOOD CONTROL
MOHAWK RIVER BASIN
COLEBROOK, N. H.
GRADATION CURVES
FOUNDATION MATERIAL AND
IMPERVIOUS AND RANDOM
EMBANKMENT MATERIAL
MOHAWK RIVER NEW HAMPSHIRE

PLATE NO. D-3

CORPS OF ENGINEERS U. S. ARMY



SPILLWAY WEIR AND STILLING BASIN SECTION & DAM AT STA 3 + 70 ±



NATURAL SCALE SECTION

CALCULATIONS

Assumptions

$k_v = 0.5 \times 10^{-4} \frac{cm}{sec}$

$k_h = 16\, k_v = (16)(0.5 \times 10^{-4}) = 8.0 \times 10^{-4} \frac{cm}{sec}$

$k_{eff} = \sqrt{k_v k_h} = \sqrt{(0.5 \times 10^{-4})(8.0 \times 10^{-4})} = 2 \times 10^{-4} \frac{cm}{sec}$

Transformation Factor $= \sqrt{\frac{k_h}{k_v}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$

Horizontal dimensions reduced by $\frac{1}{4}$

Quantity of Seepage

Q = Quantity of seepage in cu ft per sec per lineal foot of spillway weir and stilling basin

Q_T = Total quantity of seepage beneath spillway weir and stilling basin in cu ft per sec

n_f = Number of flow lines = 4

n_d = Number of head drops = 9.5

h = Head of water = 14.5'

30.5 = Factor to change cm to ft.

L = Length of spillway & stilling basin = 212'

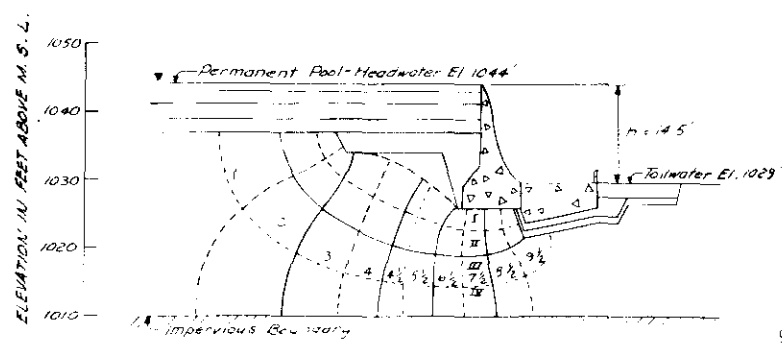
$Q = \frac{n_f}{n_d} k_{eff}\, h$

$= \left(\frac{4}{9.5}\right)\left(\frac{2 \times 10^{-4}}{30.5}\right)(14.5)$

$Q = 0.00004$ cfs/ft

$Q_T = (L)(Q) = (212)(0.00004)$

$Q_T = 0.009$ cfs



TRANSFORMED SECTION

GRAPHIC SCALE
1" = 10'
10' 0 10' 20'

CONNECTICUT RIVER FLOOD CONTROL
MOHAWK RIVER BASIN
COLEBROOK, N.H.
SEEPAGE STUDY
SPILLWAY WEIR
AND STILLING BASIN
MOHAWK RIVER NEW HAMPSHIRE

PLATE NO. D-4

TEST DATA SUMMARY

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS: GRAVEL %	SAND %	FINES %	D_{10} mm	ATT. LIMITS: LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT: TOTAL	-NO 4	COMPACTION DATA, STND AASHO: OPT. WATER % DRY WT	MAX DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT: TOTAL	-NO 4	OTHER TESTS: SHEAR	CONSOL	PERM.
FD-1	1042	J-5	3.3- 5.0	SM	39	45	16	0.04													
		J-10	10.0-15.0	SP-SM	31	59	10	0.09													
FD-2	1081	J-18	30.0-33.7	SP-SM	69	22	9	0.10													
		J-24R	40.0-45.0	SM	4	75	21	0.025													
FD-3	1038	J-6	5.0-10.0	GP-GM	61	31	8	0.14													
		J-12	15.0-20.0	SP-SM	31	57	12	0.05													
FD-4	1036	J-6	6.0- 7.6	GP-GM	52	39	9	0.05													
		J-12	15.0-20.0	GM	50	36	14	0.12													
FD-5	1038	J-9	10.0-15.0	SM	35	51	14	0.02													
FD-6	1038	J-6	5.0- 7.6	GP-GM	57	35	8	0.12													
		J-9	10.0-15.0	SP-SM	37	51	12	0.05													
FD-7	1048	J-2	0.7- 5.0	GM	47	40	13	0.04													

* PROVIDENCE VIBRATED DENSITY TEST

TEST DATA SUMMARY

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT WATER CONTENT % DRY WT		COMPACTION DATA STND AASHO		COMPACTION DATA	NAT. DRY DENSITY LBS/CU FT		OTHER TESTS		
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL	PERM
FT-1	1036	B-2	0.9- 5.3	GP	52	44	4	0.13													
FT-3	1041	B-4	3.8- 6.4	GP-GM	56	35	9	0.10													
FT-4	1040	B-2	1.4- 6.4	GP	54	44	2	0.20													
FT-7	1046	B-4	2.1- 7.4	GP-GM	56	37	7	0.15													
FT-8	1048	B-4	2.9-12.0	SP-SM	42	49	9	0.09													
BTT-1	1120	B-4	2.5-12.0	SM	24	54	22	0.037													
BT-1	1060	B-2	1.0- 4.0	SM	39	42	19	0.03													

* PROVIDENCE VIBRATED DENSITY TEST

MOHAWK RIVER DAM

APPENDIX E

STRUCTURAL DESIGN

COMPUTATIONS

APPENDIX E

STRUCTURAL DESIGN

COMPUTATIONS

R 5/26/65

APPENDIX E

STRUCTURAL DESIGN

1. PURPOSE

This section of the design memorandum presents the design criteria, basic data and assumptions used in the structural design of the appurtenant structures. A brief description of the structures with loading conditions and assumptions used is included to show the design procedures. Typical computations are inclosed in the Appendix showing the maximum conditions for the critical structures.

2. SCOPE

The structural design of the spillway abutment walls, spillway and fish ladder are included herein. Computation sheets DM-9a to DM-9e have been added modifying the shape of the weir to one having a sloping base and investigating it for Case III loading. The analysis includes an additional 100 feet of impervious blanket as requested and the sloping base permits development of sufficient passive resistance to take the horizontal forces without relying entirely on base friction as was the previous case. Cases I and II are not included herewith, as the change in shape does not critically change the values found on the original analysis.

3. DESIGN CRITERIA

a. General - All working stresses conform to those specified in the Engineering Manual 1110-1-2101, "Working Stresses for Structural Design", dated 1 November 1963. Loading conditions, design assumptions and other design criteria are based on the following applicable parts in the Engineering Manual for Civil Works; Standard Practice for Concrete (EM 1110-2400, new draft copy); and Retaining Walls (EM 1110-2-2502, 29 May 1961). Accepted engineering practice has been employed in cases where the Engineering Manual for Civil Works does not apply.

b. Concrete - The following table lists the concrete and reinforced concrete stresses used in the design of structures.

(1) All concrete except concrete fill.

Flexure	Lbs. per Sq. In.
Extreme fiber stresses in compression	1050 (3000# conc.)
Extreme fiber stresses in tension (plain conc.)	60
Shear (v)	60
Bond (u) Deformed Bars	
Top bars	210
All others	300
Modular Ratio-(n)	9

(2) Concrete fill

Extreme fiber stresses in compression	750 (2000# conc.)

c. Reinforcement

(1) Grade and working stresses - All reinforcement in the structures including temperature and shrinkage reinforcement was designed for the working stresses of new billet steel, intermediate grade, deformed bars which is 20,000 p.s.i. in flexural tension. The reinforcement will conform to the requirements of Federal Specification QQ-S-632, Type II, Grade C and to ASTM A-305-56T.

(2) Minimum cover for the main reinforcement - The minimum cover from main steel reinforcement to surface was maintained at three inches.

(3) Splices - All splices will be lapped 24 diameters to develop by bond, the total working strength of the bars.

(4) Temperature and shrinkage reinforcement - Temperature and shrinkage reinforcement will be provided where the main reinforcement extends in only one direction. Such reinforcement will provide for a ratio of steel area to concrete area (bd) of 0.002 with a minimum of .0012 in each face up to a maximum of #6 bars at 12 inches cc.

4. BASIC DATA AND ASSUMPTIONS

a. General Data

Top of dam	Elevation	1054.0
Spillway crest	"	1044.0
Maximum water surface just upstream at spillway weir	"	1051.0
Maximum tailwater	"	1042.0

b. Loads

(1) Dead loads - The following unit weights for materials were used:

Material	Unit Weight (Lbs/cu.ft.)			
	Dry	Saturated	Moist	Submerged
Earth fill	130	145	140	83
Concrete (plain and reinforced)	150			

c. External water pressure - Triangular distribution of the water pressure in the reservoir pool on the structures was used. Lateral tailwater pressure was taken at 60 percent of full value for the spillway section.

d. Internal water pressure - Uplift pressure under structures was assumed effective on 100 percent of the area of the base, varying by the creep method from tailwater head at the end of the stilling basin or toe of slope, to full headwater at the upstream edge of the impervious blanket.

e. Earth pressure - Earth pressures were determined in general accordance with EM 1110-2-2502, "Retaining Walls", dated 29 May 1961. "At rest" pressures were not used as the structures are founded on earth.

f. Earthquake forces - Because of the small size of the structures involved, earthquake forces are not a factor and were disregarded.

g. Ice pressure - Horizontal forces due to ice pressure were included in the design of the weir. A value of 6000 lbs. per linear foot was used.

h. Frost protection - A minimum frost protective cover of six feet above foundation level will be used for all structures.

i. Allowable soil bearing - The maximum allowable soil bearing was determined to be 6000 p.s.f.

5. SPILLWAY WEIR

a. Description - The spillway weir is 215 feet in length with crest elevation at 1044.0 msl. The weir is founded on earth and the abutment of the south side will be a gravity section and on the north side a combination of gravity section and fish ladder. Construction joints will be at approximately 27 feet ± on center.

b. Stability - Because of the earth foundation, it was necessary to adopt a section with a 11.19-foot extension at the heel and to utilize an impervious blanket extending approximately 180 feet upstream of the weir face. This was done to reduce the effect of the uplift. The stilling basin extension has been separated by a construction joint from the weir section. The following conditions were investigated in the design:

Case I - Reservoir empty and dead load only.

Case II - Reservoir to spillway crest minimum tailwater at elevation 1029.5. Uplift varying from maximum headwater at the upstream edge of the impervious blanket at the heel to 0 at the ground surface at the end of the stilling basin. An ice thrust of 6000# per linear foot applied to the spillway crest and the resultant to fall within the middle third.

Case III - Reservoir at maximum surcharge elevation of 1051.0 and maximum tailwater elevation of 1042.0. Uplift varying from maximum headwater at the upstream edge of the impervious blanket at the heel and varying to maximum tailwater elevation at the downstream edge of the stilling basin. Resultant to fall within the middle third.

c. Design results

(1) Weir Section - Investigation of the weir section revealed a maximum bearing pressure of 1540 p.s.f. during the construction condition. The resultant falls within the middle third for all cases.

(2) Stilling basin section - The maximum bearing value was found to be 415 p.s.f. and the resultant falls at the quarter point for Case III loading.

6. GRAVITY ABUTMENT WALLS

a. Description - The gravity abutment walls on the south side and the return section carried into the dam embankment for both abutments will be composed of monoliths approximately 25 feet long having a back slope of 1 to 3 and a front slope of 1 to 6.

b. Stability - The gravity walls were investigated for the following conditions of loading:

Case I - Construction condition with dead load only.

Case II - Reservoir empty - embankment saturated, uplift determined as for spillway weir and resultant to fall within the middle third.

Case III - Reservoir at maximum flood pool, embankment above tailwater elevation saturated uplift determined as for spillway weir, and resultant to fall within the middle third.

c. Design Results - Maximum bearing pressure was found to be 4890 p.s.f. under Case II loading and the resultant fell within the middle third for all cases. The section investigated and included in the appendix is within the embankment sections of the northside.

The south abutment wall will have a smaller restraining load from the water side but it is of such small consequence that the computations presented are considered typical for both abutments.

7. FISH LADDER

a. Description - The fish ladder section is 20 feet wide and 75 feet in length. The concrete 1'-0" below the elevation of the ladder steps will be a 2000 pound concrete founded on earth. The walls and base thickness above the lighter strength concrete will be structural concrete.

b. Stability - One condition of stability was investigated with the reservoir empty and the embankment behind the ladder saturated. No lateral forces were considered on the channel side. The resultant falls in the middle third and maximum bearing pressure is 2750 p.s.f.

c. Design - The walls of the fish ladder were designed as cantilever from the massive base section. Design requirements are low and steel will be nominal #6 bars at 1'-0" cc.

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Concrete Weir - Stability
COMPUTED BY P.D.M. CHECKED BY [illegible] DATE

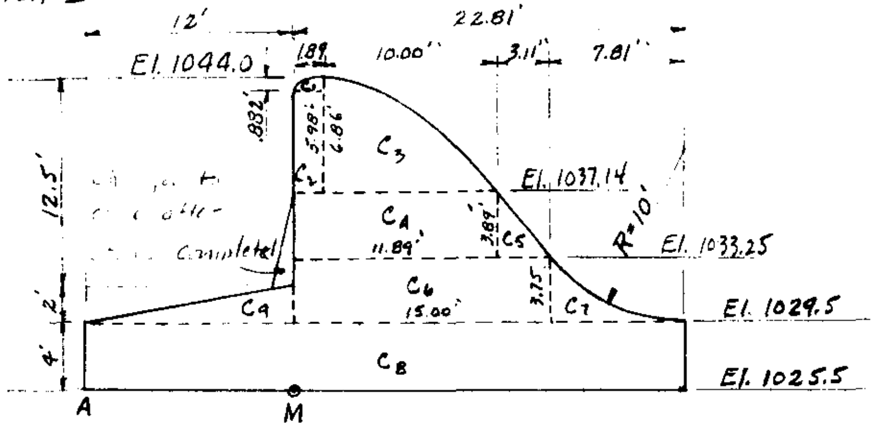
Loading Conditions

Condition I - Construction Condition
Dry
Resultant within mid third
Wind not considered effective.

Condition II - Normal Operating Condition
Pool at Spillway Crest.
Minimum Tailwater.
Ice Pressure - 6000#/lin. ft at spillway crest.
Resultant within Mid-third.
Maximum $\frac{\Sigma H}{\Sigma V} = .57$

Condition III - Flood Discharge Condition
Reservoir at Max. Flood Pool Elevation.
Tailwater at Flood Elevation.
Tailwater at Full Value for Uplift.
Tailwater at 60% of Full Value for Lateral Forces.
Resultant within Mid-third.
Max. $\frac{\Sigma H}{\Sigma V} = .57$

Condition I



Area of C_3

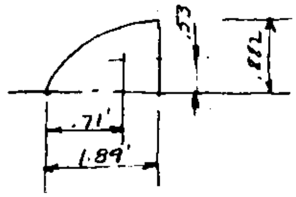
$$y = 6.86 - .0956x^{1.85}$$
$$dA = y\,dx$$
$$dA = 6.86\,dx - .0956x^{1.85}\,dx$$
$$\text{Area } C_3 = \int_0^{10} 6.86\,dx - \int_0^{10} .0956x^{1.85}\,dx = \left[6.86x\right]_0^{10} - \left[\frac{.0956x^{2.85}}{2.85}\right]_0^{10}$$
$$= 68.6 - 23.75 = \underline{44.85} \text{ sq. ft.}$$

$$dM_{y_3} = \int_0^{10} 6.86x\,dx - \int_0^{10} .0956x^{2.85}\,dx =$$
$$M_{y_3} = \left[\frac{6.86x^2}{2}\right]_0^{10} - \left[\frac{.0956x^{3.85}}{3.85}\right]_0^{10} = 343 - 175.92 = 167.08$$
$$\bar{x}_3 = \frac{M_{y3}}{A} = \frac{167.08}{44.85} = 3.73''$$

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Concrete Weir - Stability
COMPUTED BY P.D.M. CHECKED BY H.C.W. DATE

Condition I (Cont'd.)
Area of C_1

$x = .375 \times 1.89 = .71$
$y = .6 \times .882 = .53$
$A = .667 \times .882 \times 1.89 = 1.11'$



Moments about M

Item	Factors	Force	Arm	↶	↷
C_1	.15 x 1.11'	.17'	.71'		.12'
C_2	.15 x 1.89 x 6.86	1.94	.95'		1.85'
C_3	.15 x 44.85'	6.73'	5.62'		37.81'
C_4	.15 x 11.89 x 3.89	6.94'	5.95'		41.28'
C_5	.15 x .5 x 3.11 x 3.89	.91'	12.93'		11.73
C_6	.15 x 15 x 3.25	7.31	7.50'		54.84
C_{7a} *	.0875 x .5 x 6.3 x 3.3	.91	18.10'		16.46
C_8	.15 x 34.81 x 4'	20.89	5.41'		112.99
C_9	.15 x .5 x 12 x 2	1.80	-4.00	7.20	
C_{7b}	.0675 x .5 x 6.3 x 3.3	.65	18.10'		11.76
		$\Sigma V = 48.25$ (49.37)		7.20	288.84

(Subtotals bracketed in margin: 26.37 / 24.91 ; 173.1 / 164.09)

* $C_{7a} + C_{7b}$ gives full weight of concrete.

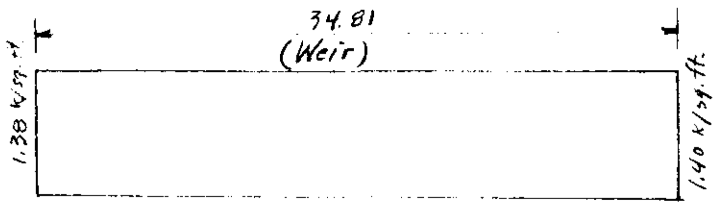
$\Sigma M = 281.64$ ↷ (281.)

$\frac{\Sigma M}{\Sigma V} = \frac{281.64}{48.25} = 5.84'$ (5.88) to right of M 17.84' from A $e = .43$ (.46)

Resultant within mid-third

$p = \frac{W}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{48.25 \; (49.37)}{34.81}\left(1 \pm \frac{6 \times .43 \; (.46)}{34.81}\right) = 1.39(1 \pm .07) = 1.39 \pm .01$ (1.54)

$p = 1.40$ (1.54) kips/sq. ft. (downstream)
$= 1.38$ (1.54, 1.33) kips/sq. ft. (upstream)



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SUBJECT Mohawk River Ice Barrier (Colebrook N.H.)
COMPUTATION Weir & Stilling Basin - Stability
COMPUTED BY R.D.M. CHECKED BY N.C.W. DATE 10/11/63

Loading Conditions
Condition II - Normal Operating Condition.
Pool at Spillway crest.
Tailwater Elev. 1029.5.
Ice Pressure - 6000#/lin. ft. @ Spillway crest.

For uplift pressures see Sheet 5. Note creep distance computed from upstream end of impervious blanket at El. 1037.0 to downstream end of stilling basin at El. 1029.5.
wt sub. soil 83, wt sat soil 145, wt moist 140, dry wt 130
Weir - Moments about M

Item	Factor	Force	Arm	↶	↷
C_{1-7a}	See Sheet No. 2	24.84 / 24.94	6.30		164.09
C_8	.15x34.81x4	47.60 ↓ 20.89'	5.41'		112.99
C_9	.15x.5x12x2	1.8'	-4.00'	7.20	
W_{w1}	.0625x12.5x12	9.38	-6.00'	56.25	
W_{w2}	.0625x.5x12x2	.75	-8.00'	6.00	
W_{w3}	.0625x.5x6.5x2	21.58 ↓ .41	20.64'		8.46
W_{ES1}	.083x12x5.5	5.47 / 10.04	-6.00'	32.87 / 60.26	
W_{ES2}	.083x.5x12x2	1.00	-8.00'	8.00	
U_1	-.516 / .579x34.81	23.37 ↑ 17.96 / -20.15	+5.41'	97.17 / 109.04	
U_2	-.5x34.81x.185	-3.22	+.40		1.29
Ice	—	6.00'	18.50'		111.00
P_{w1}	.5x.438x7	1.53	13.83'		21.20
P_{w2}	.5x.326x11.5	16.27 → 1.87	3.83		7.18
P_{w3}	.438x11.5	5.04	5.75'		28.96
P_{ES1}	.5x.318x11.5	1.83	3.83'		7.00
P_{w8}	-.125x4	← .50	+2.00'	1.00	
P_{w9}	-.5x.25x4	← .50	+1.33'	.67	

$$\frac{\Sigma H = 15.27}{\Sigma V = 45.81 \;(44.55)} = .33 \;(.34)$$

248.42 462.17

$\Sigma M = 213.75$ (232.94) ^{1K}

$\frac{\Sigma M}{\Sigma V} = \frac{213.75}{45.81}$ = 4.67 (5.68) downstream from M or 16.67 below heel

$p = \frac{W}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{45.81 \;(44.55)}{34.81}\left(1 \pm \frac{6 \times .74 \;(.28)}{34.81}\right) = 1.32 \pm .13$ (1.048 .95) = 1.45 k/sq. ft. at heel (upst'm)
1.19 k/sq. ft. at toe (downstrm)

34.81'
(Weir)

Upstream 1.46 k/sq.ft (1.85) | 1.19 k/sq.ft (1.05) Downstream

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Weir & Stilling Basin . . Stability
COMPUTED BY P.D.M. CHECKED BY DATE

Stilling Basin - Moments abt B

Item	Factors		Force	Arm	↶	↷
C_{10}	.15x44.08x4'		26.45'	22.04'		582.91'
C_{13}	.15'x.5'x44.08x2	34.01	6.61'	14.69'		97.13'
C_{12}	.0875x2x2		.35'	22.58'		7.90'
C_{11}	.15x2x2		.60'	43.08'		25.85'
W_{w4}	-.0625x42.08x2		5.26	21.04'		110.67'
U_3	-.334x44.08'	22.63	14.72	22.04'	324.49'	
U_4	-.5x.359x44.08		7.91'	14.69'	116.23'	
P_{w4}	.5x.25x4'		.50'	1.33'		.67'
P_{w5}	.125x4'		.50'	2.00'		1.00'
P_{w6}	.579x2	3.24	1.16	-1.00'	1.16	
P_{w7}	.5x.114x2		.11	-.67'	.08	
P_{ES2}	.4x2		.8	-1.00'	.80	
P_{ES3}	.5x.17x2		.17	-.67'	.11	
P_{w10}	-.125x4'		.5	2.00'	1.00	
P_{w11}	-.5x.25x4'	2.53	.5	1.33'	.67	
P_{ES4}	-.5x.166x6		.50	.00'	—	—
P_{w12}	-.334x2		.67	-1.00		.67
P_{w13}	-.5x.359x2		.36	-.67'		.24

$\Sigma H = .71 = .04$ 444.54   827.04

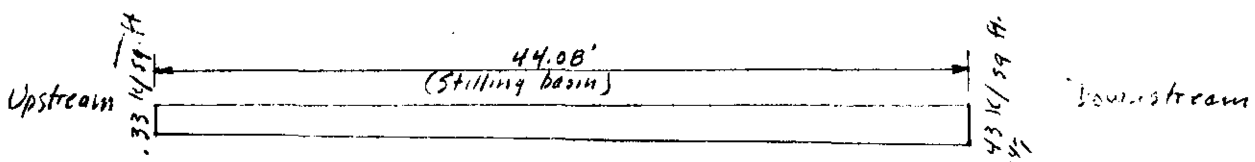
$\Sigma V = 16.64$ $\Sigma M = 382.50$

$\frac{\Sigma M}{\Sigma V} = 22.99'$ from B.

$e = 22.99 - 22.04 = .95$

$$p = \frac{W}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{16.64}{44.08}\left(1 + \frac{6 \times .95}{44.08}\right) = .38 \pm .05$$

p = .43 k/sq.ft @ downstream end.
.33 k/sq.ft. @ upstream end.



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SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Weir & Stilling Basin - Stability
COMPUTED BY PDM CHECKED BY DATE 10/11/63

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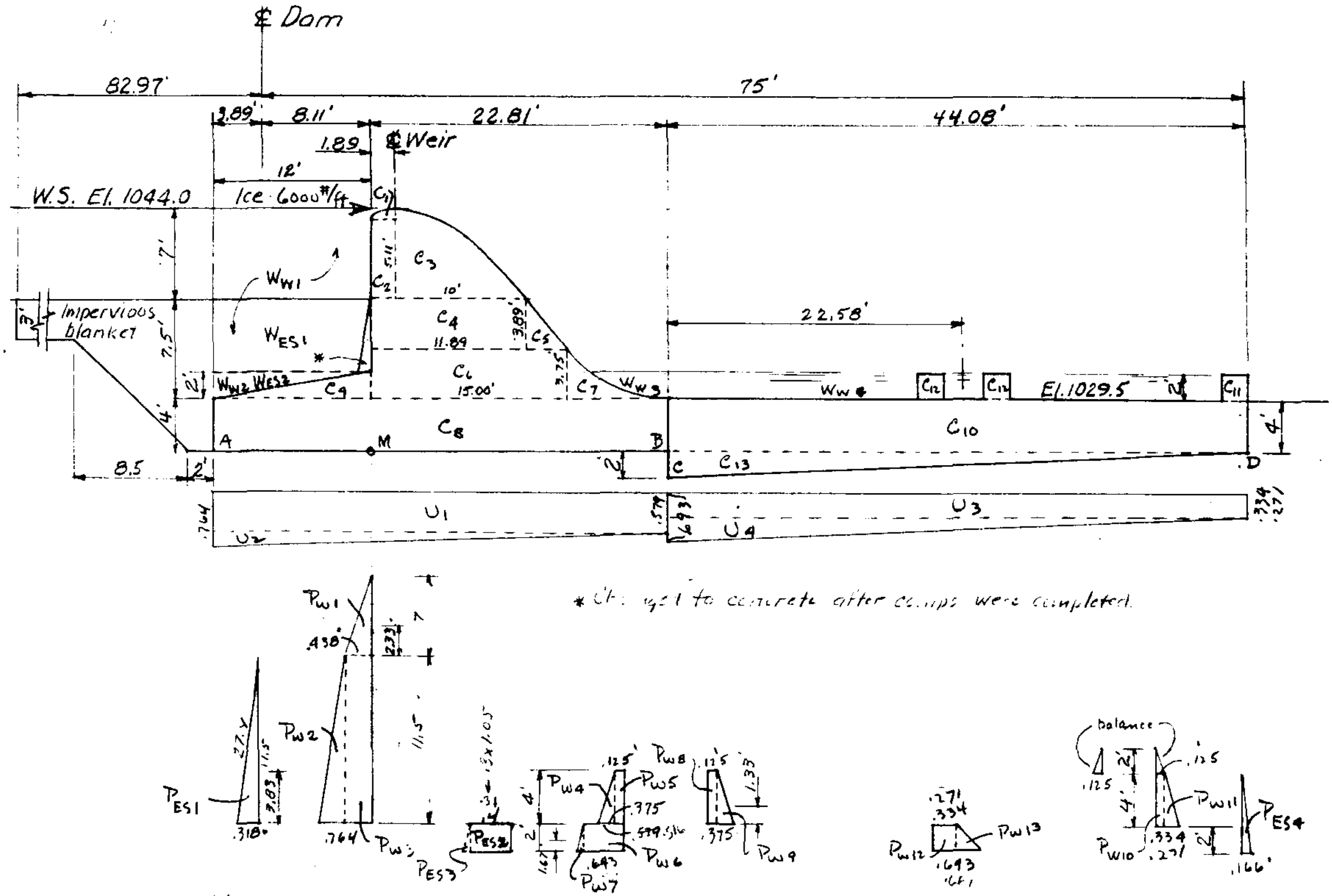


Creep ratio = $\frac{\text{creep distance}}{\text{net head}} = \frac{170.54'}{14.5'} = \frac{11.76'}{1}$

Seepage potential		Position Potential	Effective Hydrostatic Pressure
@ A	$\frac{84.94' \times 14.5'}{170.54'} = 7.22'$	5'	$(7.22' + 4.5)\,.0625 = .764$ k/sq. ft. (.731)
@ B	$\frac{50.13' \times 14.5}{170.54'} = 4.26'$	5.4	$(4.26 + 5)\,.0625 = .579$ .516
@ C	$\frac{48.13' \times 14.5}{170.54} = 4.09'$	7 6	$(4.09 + 7)\,.0625 = .693$ .661
@ D	$\frac{4 \times 14.5}{170.54} = .34$	5.4	$(.34 + 5)\,.0625 = .334$ .271

(20.32 c.y.)

SUBJECT Mohawk River Ice Barrier (Colebrook N.H.)

COMPUTATION Weir & Stilling Basin - Stability

COMPUTED BY PDM CHECKED BY [illegible] DATE 10/9/62

Condition III

Weir Moments about M. See Sheet 8

Item	Factors	Force	Arm	↙	↖
C_{1-7}		47.60 ↓ 24.91 (26.04)	6.30		164.17
C_8	.15x34.81x4	20.89	5.41'		112.99
C_9	.15x12x2x.5	1.80	-4.00'	7.20	
$W_{w}1$	.0625x12x21 (19)	19.43 ↓ 15.75	-6.00	94.50	
$W_{w}2$	.0625x12x2x.5	.75	-8.00'	6.00	
$W_{w}3$	.0625x7.81x6	2.93	18.91'		55.38
$W_{ES}1$	.083x7.5x12 (5.5)	8.09 ↓ 7.47	-6.00'	44.82	
$W_{ES}2$	.083x7.5x2x.5	.62	-8.00'	4.95	
U_1	-1.192x34.81	43.51 ↑ 41.49	5.41'	224.48	
U_2	-.116x34.81x.5	2.02	-.40		.81
$P_{w}1$	.438x7	17.15 → 3.07	15.00'		45.99
$P_{w}2$	.875x11.5	10.06	5.75'		57.86
$P_{w}3$	.437x7x.5	1.53	13.83'		21.15
$P_{w}4$	.433x11.5x.5	→ 2.49	3.83'		9.54
$P_{w}5$	-.594x9.5x.5	← 2.82	3.17	8.94	
$P_{ES}1$	.318x11.5x.5	→ 1.83	3.83		7.00

$\Sigma H = 16.16 = .51$ (.52) $< .57$ 390.92   474.89

$\Sigma V = 31.61$ (31.12) $\Sigma M = 83.97$ (92.84)

Concrete per foot

$\frac{47.60}{.15\times 27} = 11.75$ cu.yds/ft.

$\frac{\Sigma M}{\Sigma V} = \frac{83.97}{31.61} = 2.66'$ from M (92.84 / 31.12 = 2.98)

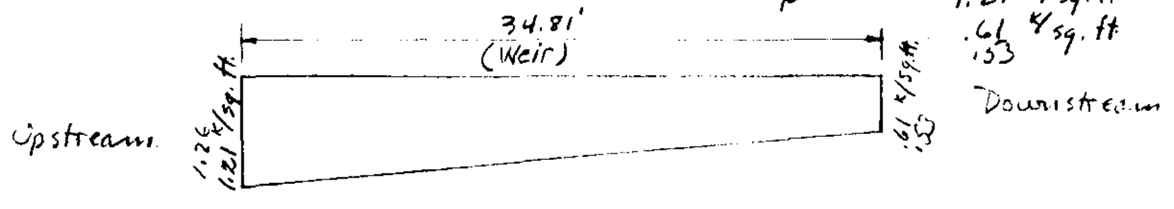
From A $12 + 2.66 = 14.66'$ (14.98)

Inside middle third

e: 17.41 - 14.98 = 2.43

$p = \frac{31.61}{34.81}\left(1 \pm \frac{6 \times 1.75}{34.81}\right) = .91 \pm .30$ (31.12; 2.43)

$p =$ 1.21 k/sq.ft (1.26)
.61 k/sq.ft (.53)



SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)

COMPUTATION Weir & Stilling Basin - Stability -

COMPUTED BY D.M. CHECKED BY H.E.W. DATE 10/9/63

Condition III

Stilling Basin Moments ab't. B See Sheet B

Item	Factor	Force	Arm	↶	↷
C_{10}	.15x 44.08'x 4'	↓ 26.45	22.04'		582.91
C_{11}	.15x 2x2	↓ .60 (33.91 ↓)	43.08'		25.85
C_{12}	.0875x2x2	↓ .35'	22.58		7.90
C_{13}	.15x 44.08x 2'x.5	↓ 6.61'	14.69'		97.13
W_{w4}	.0625x 42.08'x6.44	↓ 16.94	21.04'		356.36
W_{w5}	.0625x.5x42.08'x6.06	↓ 7.97 (25.24 ↓)	28.05'		223.53
W_{w6}	.0625x 10.5'x 2'	↓ $\overset{1.31}{.33}$	43.08'		$\overset{56.51}{14.14}$
P_{w7}	.25x 4x .5	→ .50	1.33'		.67
P_{w6}	.406x4	→ 1.62	2.00'		3.25
P_{w8}	-.263'x x4'x.5	← .53	1.33'	.70	
P_{w8}	-.781x 4	← 3.12	2.00'	6.24	
P_{ES2}	$\overset{.100}{.332}$x4x.5	← .66	1.33	0.27	
U_3	-1.044x 44.08	↑ 46.02	22.04'	1014.27	
U_4	-.264x44.08'x.5	↑ 5.82 (51.84 ↑)	14.69'	85.47	
P_{w10}	1.190x2	→ 2.38	-1.00'	2.38	
P_{w11}	.118x.5'x2	→ .12	-1.33'	.16	

$\Sigma H = \overset{.177}{.31} \rightarrow = \overset{.09}{.04}$ 1109.22 1311.74

$\Sigma V = \underset{8.39}{7.31} \downarrow$ $\Sigma M = \underset{244.62}{202.52}$

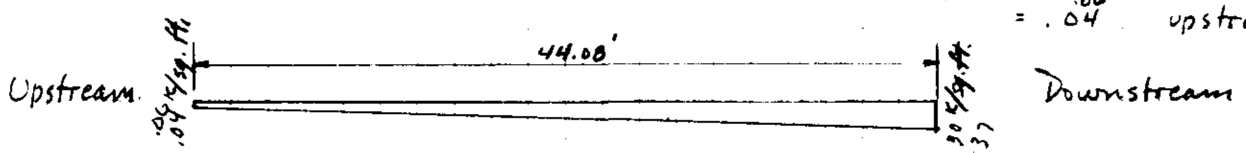
$\dfrac{\Sigma M}{\Sigma V} = \dfrac{\overset{244.62}{202.52}}{\underset{8.39}{7.31}} = \overset{29.15}{27.70}'$ from B

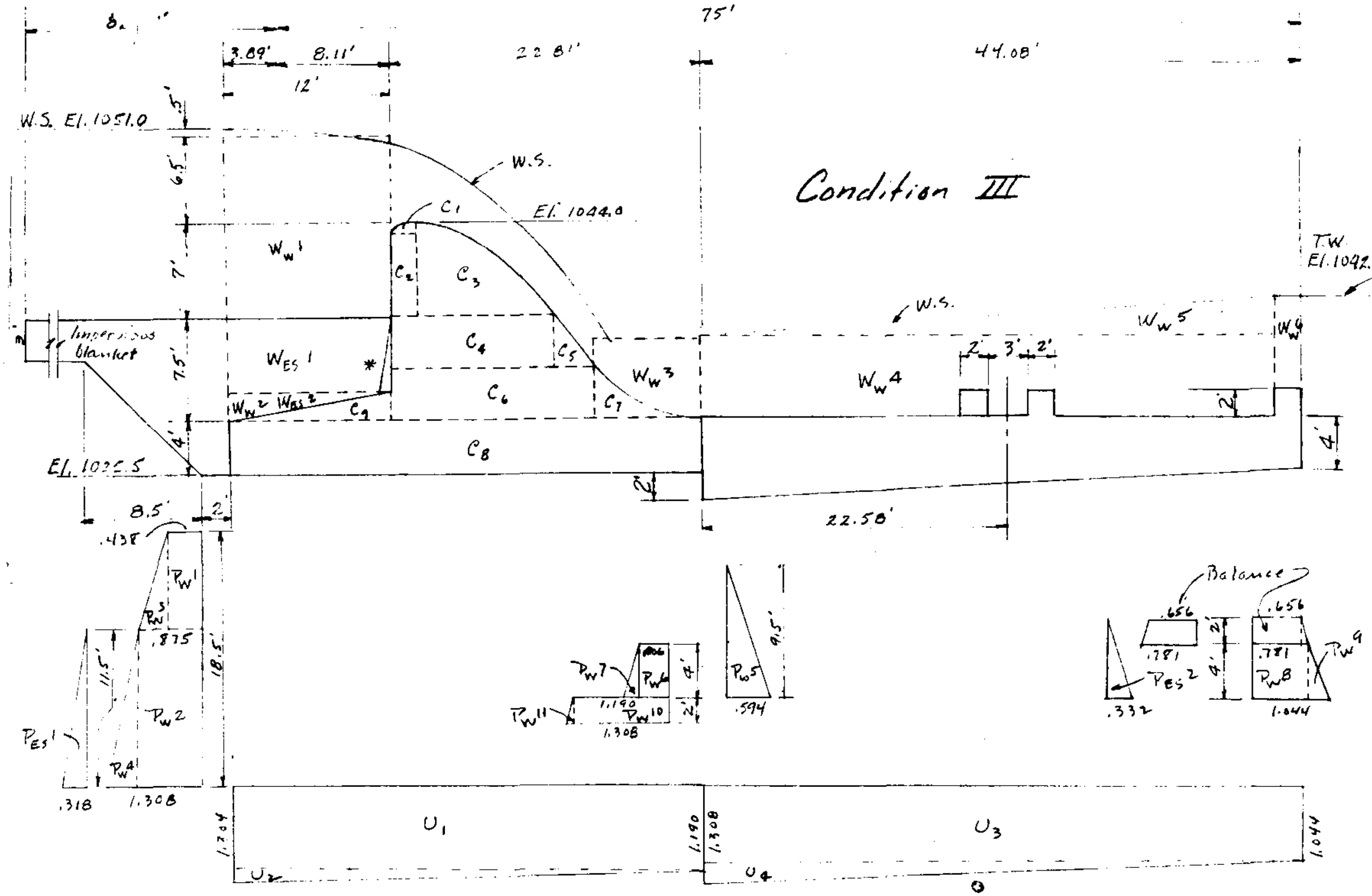
33.91^{k} conc $= \dfrac{33.91}{.15\times 27} = 8.37$ c.y.

Total yardage per foot for Weir and Stilling Basin
11.75 + 8.37 = 20.12 cubic yards.

$$p = \frac{W}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{\overset{8.39}{7.31}}{44.08}\left(1 \pm \frac{6\times \overset{7.11}{5.66}}{44.08}\right) = .17 \pm .13$$

p = $\overset{.37}{.30}$ $\underset{.66}{}$ downstream
= .04 upstream





Creep Ratio = $\frac{\text{creep distance}}{\text{net head}}$

Creep distance = 3 + 68.58 + 12.02 + 2 + 34.81 + 2 + 44.13 + 4 = 170.54

Net head = 9'

Seepage Potential - @A $\frac{\overset{84.94}{\cancel{82.54}}}{170.54}\times 9 = \overset{4.48}{\cancel{4.37}}$, @B $\frac{\overset{50.05}{\cancel{45.05}}}{170.54}\times 9 = \overset{2.64}{\cancel{2.54}}$, @D $\frac{\overset{48.05}{\cancel{46.05}}}{170.54}\times 9 = \overset{2.54}{\cancel{2.43}}$, @C $\frac{4}{170.54}\times 9 = .021$

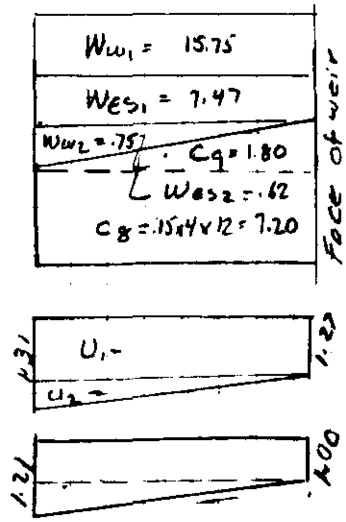
Effective Hydrostatic Hd. @A $(\overset{4.45}{\cancel{4.37}} + 16.5).0625 = \overset{1.31}{1.304}$, @B $(\overset{2.64}{\cancel{2.54}} + 16.5).0625 = \overset{1.195}{1.190}$, @D $(\overset{2.54}{\cancel{2.43}} + 18.5).0625 = \overset{1.315}{1.308}$

@C, (.21 + 16.5).0625 = 1.044   Position potential @A 16.5, @B 16.5, @D 18.5, @C 16.5

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT: Mohawk River Ice Barrier (Colebrook N.H.)
COMPUTATION: Weir + Stilling Basin - Heel Design
COMPUTED BY: H.E.W. CHECKED BY: DATE:



$M = 30.42 \times 6 + 1.37 \times 8 + 1.80 \times 4 - 1.27 \times 6 \times 12 - .04 \times 12 \times .5 \times 8$
$- 1.00 \times 12 \times 6 - .21 \times 12 \times .5 \times 8 =$
$182.52 + 10.96 + 7.20 - 91.4 - 1.92 - 72 - 10.10 = 25.26^{k}$

$A_s = \dfrac{25{,}260 \times 12}{20{,}000 \times .867 \times 67} = .26$ use #6 e 1'-0" cc

$V = 15.75 + 7.47 + .75 + 1.80 + .62 + 7.20 - 1.27 \times 12 - .40 \times \frac{12}{2}$
$= 18{,}110^{\#}$

$v = \dfrac{18{,}110}{12 \times .867 \times 67} = 26$ #/□"

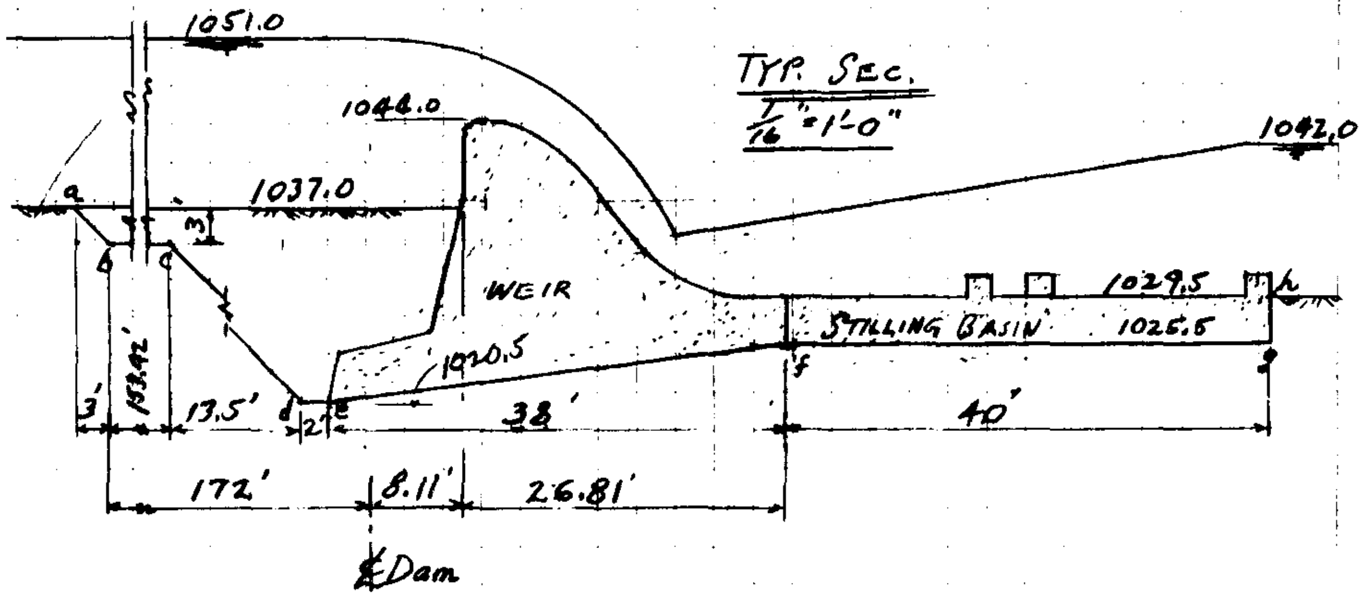
$u_o = \dfrac{18110}{2.36 \times .867 \times 67} = 132$ #/□" OK

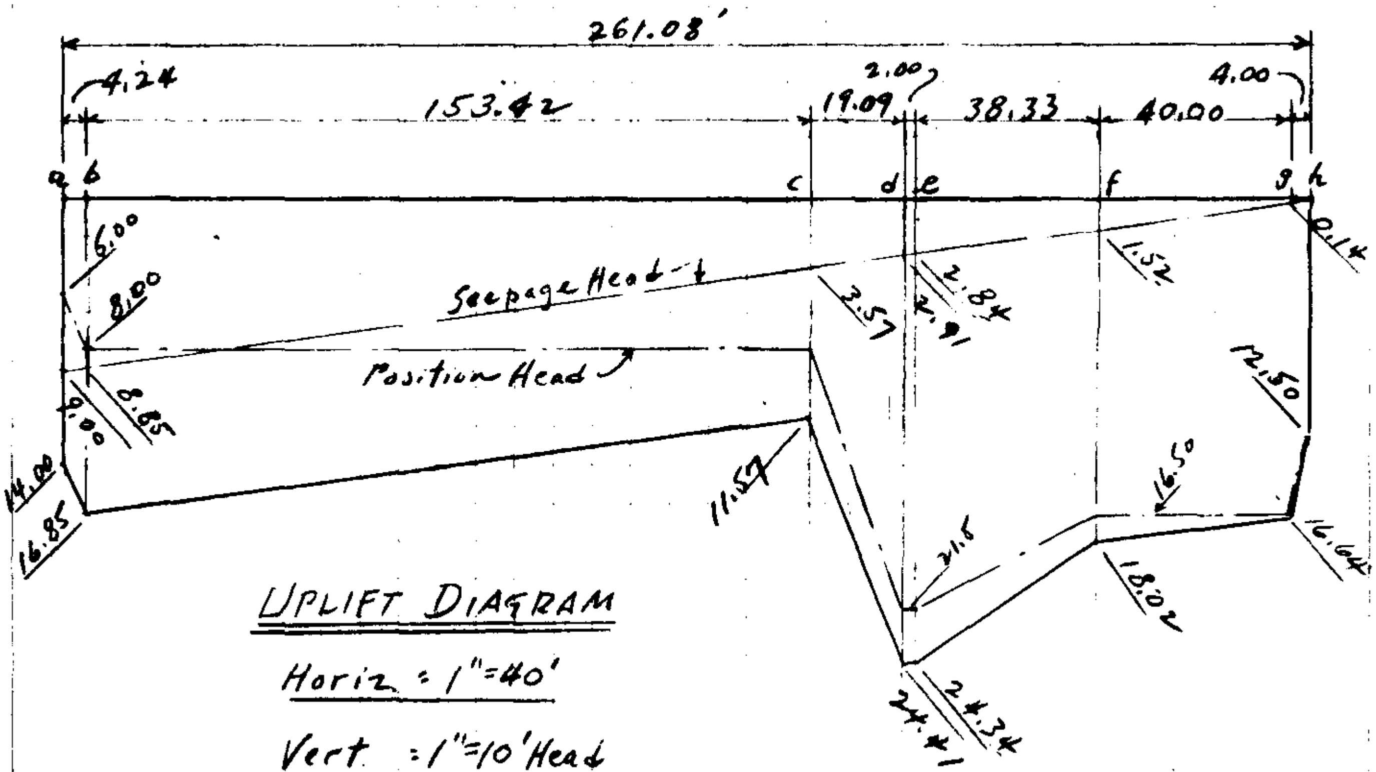
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Mohawk - Colebrook
COMPUTATION
COMPUTED BY C.C.C. CHECKED BY R.A.K. DATE 5-5-65

CONDITION III





UPLIFT DIAGRAM

Horiz. = 1" = 40'

Vert. = 1" = 10' Head

NED FORM 223
27 Sept 49

CORPS OF ENGINEERS, U.S. ARMY

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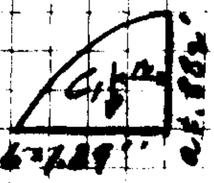
SUBJECT: MOHAWK - COLEBROOK

COMPUTATION:

COMPUTED BY: C.L.C.   CHECKED BY: R.A.K.   DATE: 5-5-65

MISC. AREAS & C.G.'s

C1: Assume simple parabola,
$A = 2ab \div 3 = 64 \square'$
$h = 3b \div 8$ $2.71'$

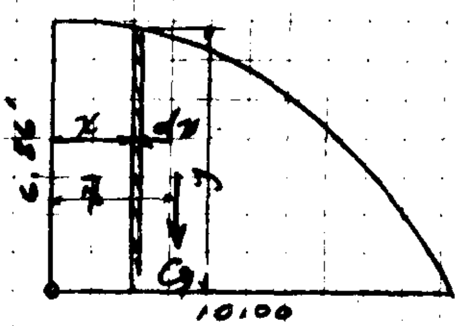


C3: $y = 6.86 - .0956x^{1.85}$

$\text{Area} = \int y\,dx = \int_0^{10} (6.86 - .0956x^{1.85})\,dx = \underline{44.85\,\square'}$

$\bar{x} = \dfrac{\int xy\,dx}{\text{Area}} = \dfrac{\int_0^{10} (6.86x - .0956x^{2.85})\,dx}{44.85} = \underline{3.73'}$

(Compare simple parab.: Area $= 2 \times 10 \times 6.86 \div 3 = 45.73\,\square'$; $\bar{x} = 3 \times 10 \div 8 = 3.75'$)

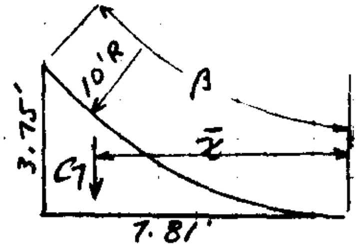


C7: $\beta = \sin^{-1} 7.81 \div 10 = 51.35° = .896\text{ rad}$ $\cos = .62456$

$\text{Area} = (\sin\beta - \frac{1}{2}\beta - \frac{1}{2}\sin\beta\cos\beta)R^2$

$= (.781 - .896 \div 2 - .5 \times .781 \times .62456)(10)^2 = \underline{8.91\,\square'}$

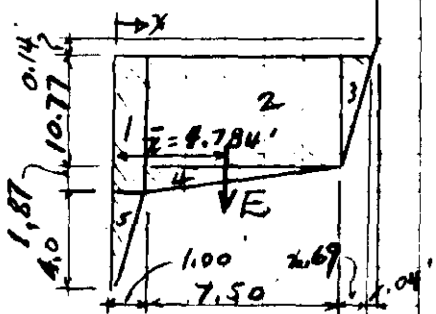
$\bar{x} = \dfrac{R^3\left(-\frac{1}{12} - \frac{\cos 2\beta}{4} + \frac{\cos^3\beta}{3}\right)}{\text{Area}} = \dfrac{(10)^3}{8.91}\left(-1 \div 12 + .21985 \div 4 + (.62456)^3 \div 3\right) = \underline{5.93'}$



E:

	$\bar{x}$	A
1	.5	10.77
2	4.75	7.5 × 10.77
3	9.397	1.345 × 10.77
4	3.5	3.75 × 1.87
5	.333	.5 × 4

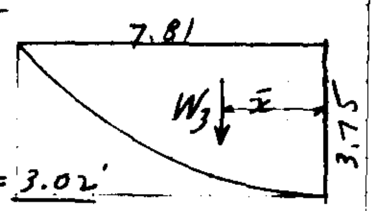
$\Sigma \bar{x} A = 550.398$
$\Sigma A = 115.043\,\square'$



W3: $\text{Area} = (\frac{1}{2}\beta - \frac{1}{2}\sin\beta\cos\beta)R^2 = (.5 \times .896 - .5 \times .781 \times .62456)100 = \underline{20.41\,\square'}$

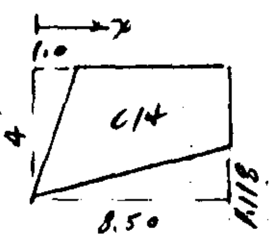
$\bar{x} = \dfrac{\left(+\frac{1}{3} - \frac{\cos\beta}{4} - \frac{\cos^3\beta}{3} + \frac{\cos\beta\cos 2\beta}{4}\right)R^3}{\text{Area}}$

$= (1 \div 3 - .62456 \div 4 - (.62456)^3 \div 3 + .62456 \times .21985 \div 4)\,1000 \div 20.41 = \underline{3.02'}$



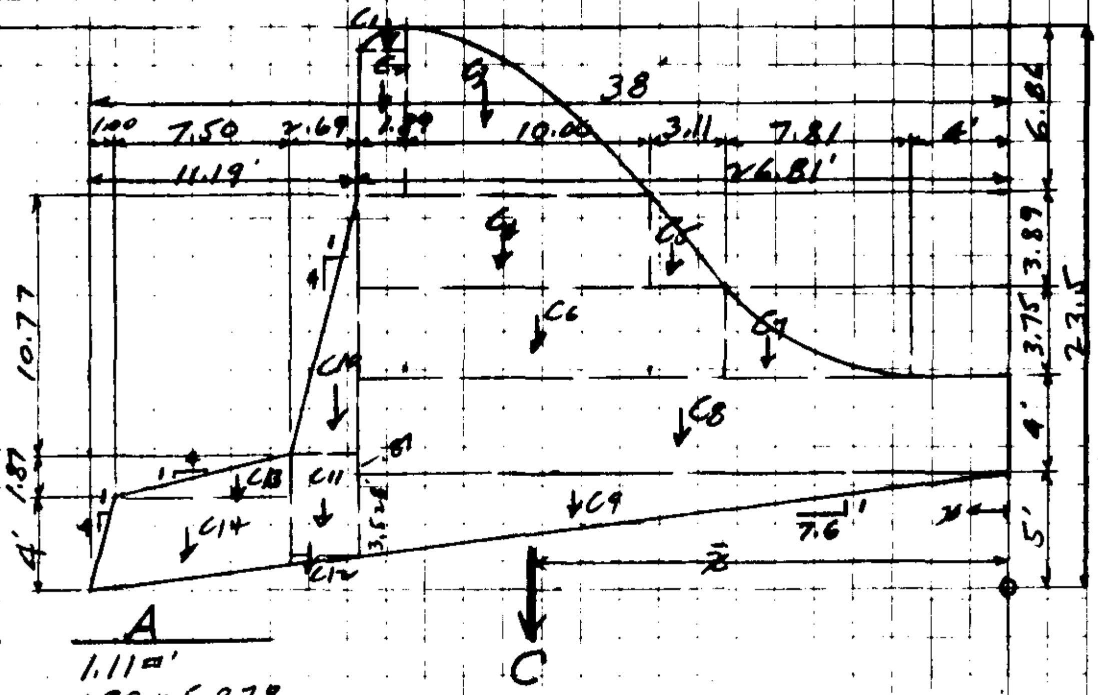
C14:
$8.50 \times 4 = 34.0 \times 4.25 = 144.5$
$-1 \times 4 \div 2 = -2.0 \times 1/3 = -.667$
$-8.5 \times 1.118 \div 2 = \underline{-4.752} \times 5.667 = \underline{-26.930}$
$27.248\,\square'$ 116.903

$\bar{x} = 4.290'$



SUBJECT: MOHAWK - COLEBROOK
COMPUTATION:
COMPUTED BY: C.C.C. CHECKED BY: R.A.K. DATE: 5-5-65

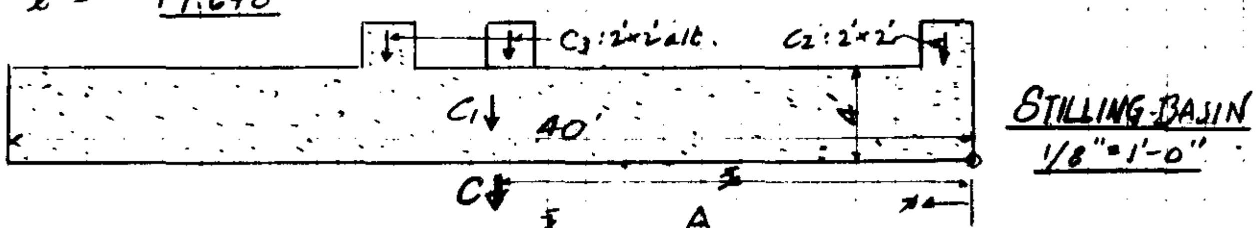
WEIR & STILLING BASIN - AREA, C.G. & VOLUME



	$\bar{x}$	A
C1	25.63	1.11 □'
C2	25.865	1.89 × 5.978
C3	21.19	44.85 □'
C4	20.865	11.89 × 3.89
C5	13.883	3.11 × 3.89 ÷ 2
C6	19.31	15 × 3.75
C7	9.93	8.91 □'
C8	13.405	26.81 × 4
C9	17.873	26.81 × 3.528 ÷ 2
C10	27.707	2.69 × 10.77 ÷ 2
C11	28.155	2.69 × 4.398
C12	28.603	2.69 × 3.54 ÷ 2
C13	32.0	7.5 × 1.87 ÷ 2
C14	33.71	27.248 □'

ΣA = 390.305 □' = 14.456 c.y.
$\Sigma \bar{x} A$ = 7668.557
$\bar{x}$ = 19.648'

Weir: 14.456 c.y./'
St. B.: 6.222
20.678
× 215'
4446. cu. yds.



	$\bar{x}$	A
C1	20	40 × 4
C2	1	2 × 2
C3	21.5	2 × 2

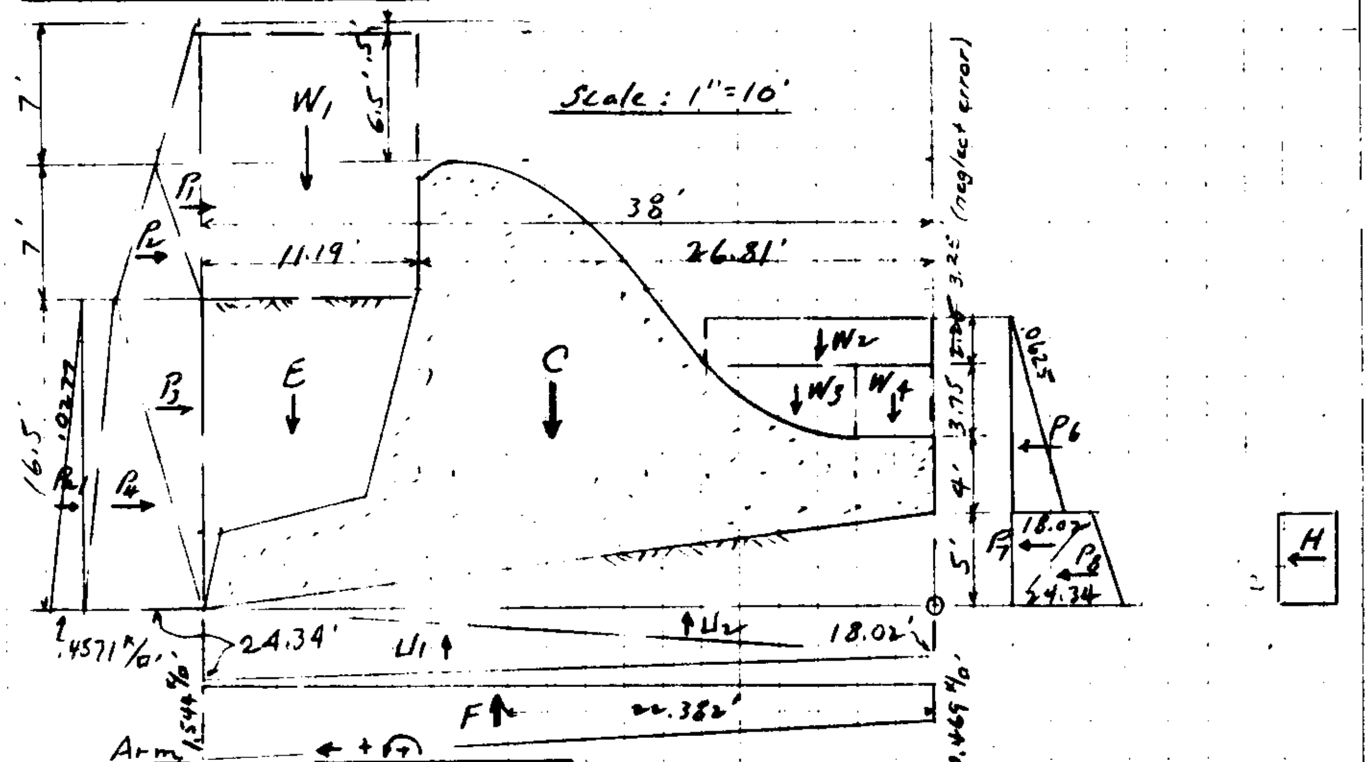
ΣA = 168 □' = 6.222 c.y.
$\Sigma \bar{x} A$ = 3290.
$\bar{x}$ = 19.583'

SUBJECT Mohawk - Colebrook

COMPUTATION

COMPUTED BY C.C.C. CHECKED BY R.A.K. DATE 5-14-65

WEIR-STABILITY-COND. III



Arm		←+ ↶
Pa1	5.5	-8.25×.4571
P1	21.167	- 7×3.5×.0625
P2	18.833	- 14×3.5×.0625
P3	11.	- 14×8.25×.0625
P4	5.5	-24.34×8.25×.0625
P6	8.333	10×5×.0625
P7	3.333	18.02×2.5×.0625
P8	1.667	24.34×2.5×.0625

Σ←+ = -18.39 k = -H

H	2.5	18.39
		↓+ ↶
C	19.648	390.305×.15
E	33.216	115.043×.145
W1	32.405	11.19×13.5×.0625
W2	5.905	11.81×2.25×.0625
W3	7.02	20.41×.0625
W4	2.	4×3.75×.0625
U1	25.333	-19×24.34×.0625
U2	12.667	-19×18.02×.0625

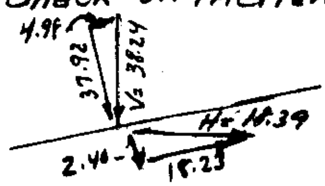
Σ←+ = 0,

Σ↓+ = 38.240 k = -F

Σ↶ = 855.895 k' ÷ F = 22.382' - 19 = 3.382' = e

f = 38.240 ÷ 38 [1 ± 6×3.382 ÷ 38] = 1.544, 0.469 k/□'

Check on friction on sloping base



ΣV = 37.92 + 2.40 = 40.32

ΣH = 18.23 - 4.98 = 13.25

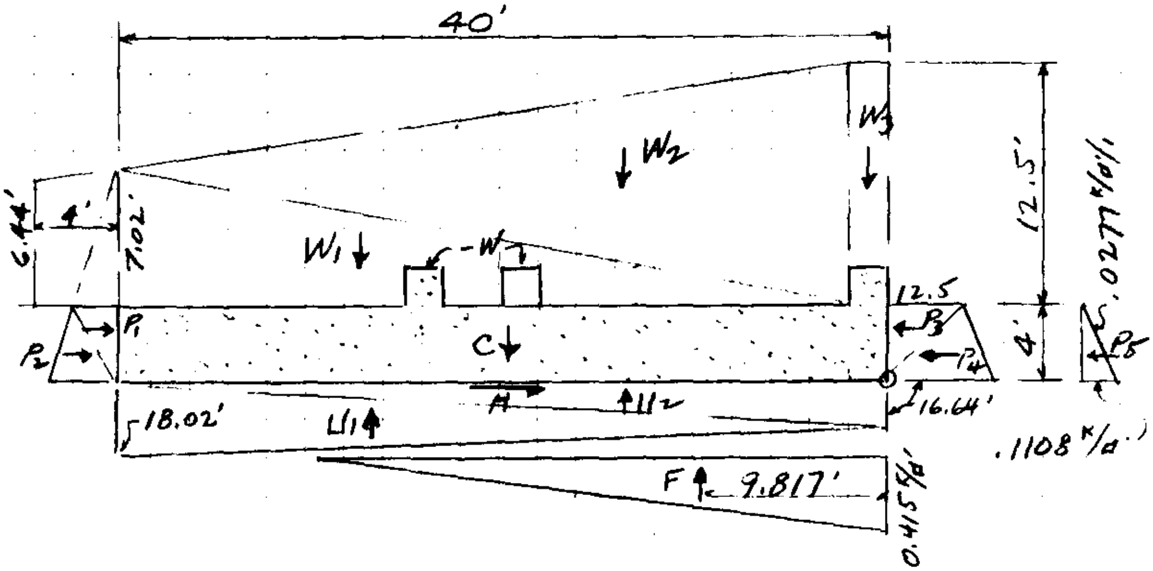
$\Sigma \frac{H}{V} = \frac{13.25}{40.32} = .33 < .37$

SUBJECT MOHAWK - COLEBROOK

COMPUTATION

COMPUTED BY C.C.C. CHECKED BY R.A.K. DATE 5-5-65

STILLING BASIN - STABILITY - COND. III



	$\bar{x}$	← + ↶+
P_1	2.667	$-2\times7.02\times.0625$
P_2	1.333	$-2\times11.02\times.0625$
P_3	2.667	$2\times12.5\times.0625$
P_4	1.333	$2\times16.64\times.0625$
P_5	1.333	$2\times.1108$
		+ ↓ ↶+
C	19.583	$168\times.15$
W_1	27.333	$19\times7.02\times.0625$
-W	21.5	$-4\times.0625$
W_2	14.667	$19\times12.5\times.0625$
W_3	1.	$2\times10.5\times.0625$
U_1	26.667	$-20\times18.02\times.0625$
U_2	13.333	$-20\times16.64\times.0625$

$\Sigma \leftarrow + = \underline{1.609}^{k} = -H$

$\Sigma + \downarrow = \underline{6.118}^{k} = -F$

$\Sigma \curvearrowleft + = 60.055^{k'} \div 6.118^{k} = \underline{9.817}'$ $< \frac{40}{4} = 10$ but close enough

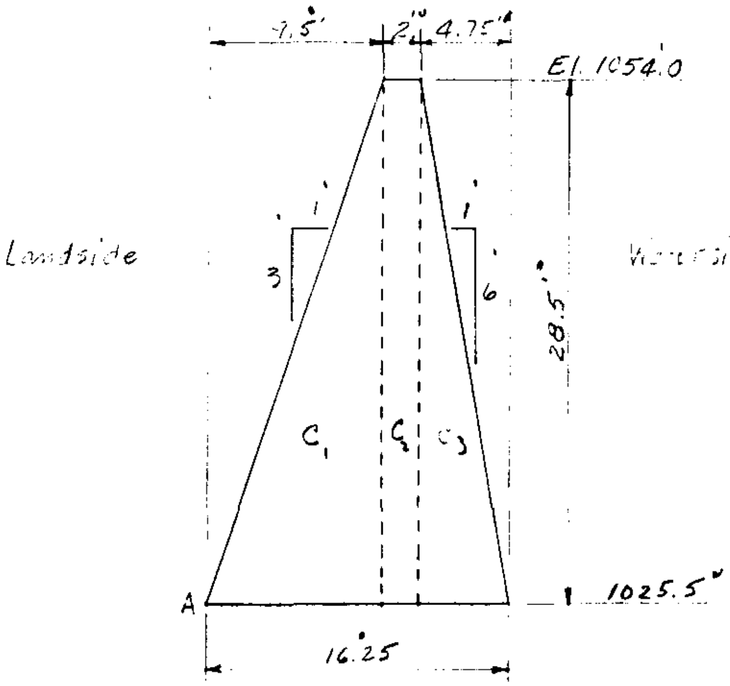
$H \div F = \underline{0.263}$ o.k.

$f = 2\times6.118\div(3\times9.817) = \underline{0.415}$ K/□' o.k.

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Mohawk River Ice Barrier (Colebrook N.H.)
COMPUTATION Wall Stability - Condition I (Note: wall on ℄ dam at exit weir adj fish ladd.)
COMPUTED BY T.D.M. CHECKED BY H.E.A. DATE



Condition I Construction Cond.
Dry.
Resultant within mid third
Wind not considered effective

For allowable bearing see next sheet.

Moments about A

Item	Factors	Force	Arm	↙	↗
C_1	.15 × .5 × 9.5 × 28.5	20.31	6.33'		128.56
C_2	.15 × 2 × 28.5	8.55	10.50'		89.78
C_3	.15 × .5 × 4.75 × 28.5	10.15	13.08'		132.76

$\Sigma V = 39.01$ k

$\Sigma M = 351.10'$

$$\frac{\Sigma M}{\Sigma V} = \frac{351.10}{39.01} = 9.00' \text{ from A within mid third.}$$

$$e = 9 - \frac{16.25}{2} = .875$$

$$P = \frac{W}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{39.01}{16.25}\left(1 \pm \frac{6 \times .875}{16.25}\right) = 2.4(1 \pm .32)$$

$$P = 2.4 + .77 = 3.17 \text{ K/sq. ft. waterside}$$

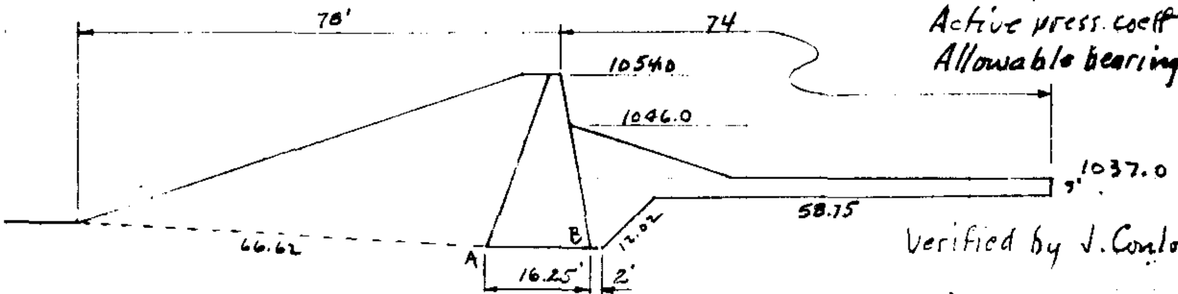
$$= 2.4 - .77 = 1.63 \text{ K/sq. ft. landside}$$

SUBJECT Mohawk River Ice Barrier (Colebrook N.H.)
COMPUTATION Wall-Stability
COMPUTED BY TDM CHECKED BY HEW DATE

Condition II
Reservoir empty.
Dam embankment saturated.
Uplift - ground water at 1037.0' at upstream end of blanket and water at ground line at downstream end of blanket (1029.5)'

Soil properties

Saturated	1.45
Moist	1.40
Dry	1.30
Submerged	.83
Friction ∠ =	30°
At rest press. coeff.	.5
Active press. coeff. =	.3
Allowable bearing	6000#/sq ft.



Verified by J. Conlon 2/25/64

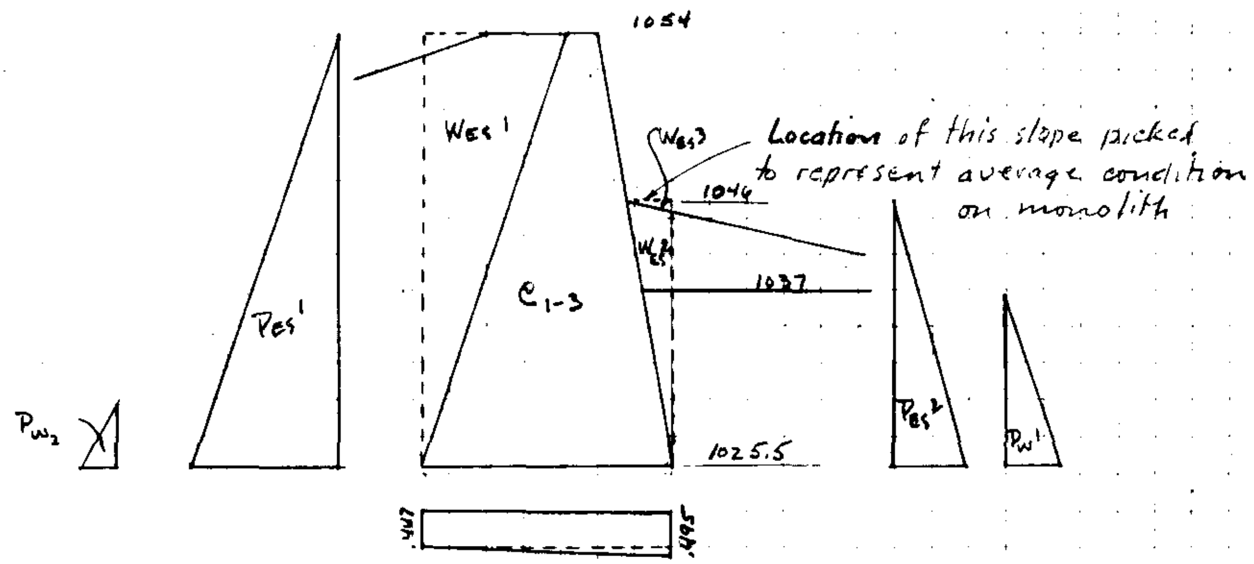
Creep distance = 3 + 58.75 + 12.02 + 2 + 16.25 + 66.62 = 158.64
Net head = 1037 - 1029.5 = 7.5'

Seepage potential — Position Potential

@ B = $\frac{82.87'}{158.64} \times 7.5 = 3.92'$ — 4'

@ A = $\frac{66.62'}{158.64} \times 7.5 = 3.15'$ — 4'

Effective hydrostatic Pressure
@ B (3.92 + 4) 62.5 = 495.00 = .495 k/sq. ft.
@ A (3.15 + 4) 62.5 = 446.88 = .447 k/sq. ft.



Note Effect of sloping fill neglected as there is a reduction on both sides and the answer as determined is conservative

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION

CORPS OF ENGINEERS, U. S. ARMY

(3)

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SUBJECT Mohawk River Ice Barrier (Colebrook N.H.)

COMPUTATION Wall Stability

COMPUTED BY RDM CHECKED BY WEW DATE

Moments about A. Active pressures

Item	Factors	Force		Arm	↗	↖
C_{1-3}		↓	39.01	9.00		351.10'
W_{ES} 1	.145 x .5 x 9.5 x 28.5	↓	19.63	3.17		62.23'
W_{ES} 2	.145 x .5 x 3.42 x 20.5	↓	5.08	15.11'		76.80'
W_{ES} 3	-.145 x .5 x 4.5 (3.4) x 1.3	↑	.42 (.32)	28.07 (15)	11.91 (4.88)	
P_{ES} 1	.3 x .145 x .5 x 28.5²	→	17.67	9.50'		167.83
P_{ES} 2	-.3 x .145 x .5 x 20.5²	←	9.14	6.83'	62.43	
P_w 1	-.0625 (.044) x 11.5² x .5	←	4.13 (2.91)	3.83'	15.83 (11.14)	
P_w 2	.0625 (.044) x 4² x .5	→	.50 (.35)	1.33		.67 (.46)
U_1	-.447 x 16.25	↑	7.26	8.13'	59.02	
U_2	-.5 x .048 x 16.25	↑	.39	10.83'	4.22	

$$\frac{\Sigma H}{\Sigma V} = \frac{4.9 \;(5.96)}{55.25 \;(55.75)} = .087 \;(.11)$$

153.41   658.63

$\Sigma M = 505.22$ (516.69)

$$\frac{\Sigma M}{\Sigma V} = \frac{505.22}{55.25} = 9.14' \text{ from A} \quad (9.27)$$

Resultant within mid-third

$$e = 9.14 \;(9.27) - \frac{16.25}{2} = 1.02 \;(1.15)$$

$$P = \frac{V}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{55.25 \;(55.75)}{16.25}\left(1 \pm \frac{6 \times 1.02 \;(1.15)}{16.25}\right)$$

$$= 3.40\,(1 \pm .75) = 5.95 \;(4.89)\ \text{k/sq ft},\ .85 \;(1.91)\ \text{k/sq. ft.}$$

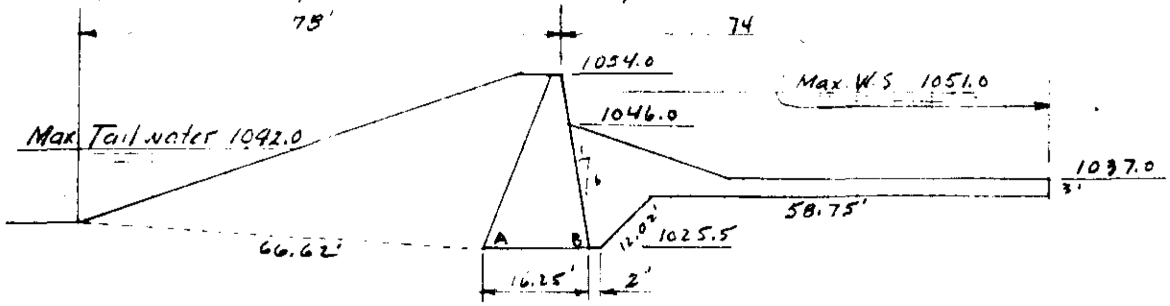
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Wall Stability
COMPUTED BY P.D.M. CHECKED BY HW DATE

Condition III

Reservoir at max. flood pool elevation (El. 1051.0) All gates open and tailwater at fixed elevation (El. 1042.0) Tailwater pressure at full value. No ice pressure.



Creep distance = 158.64'

Net head = 1051.0 − 1042.0 = 9.00'

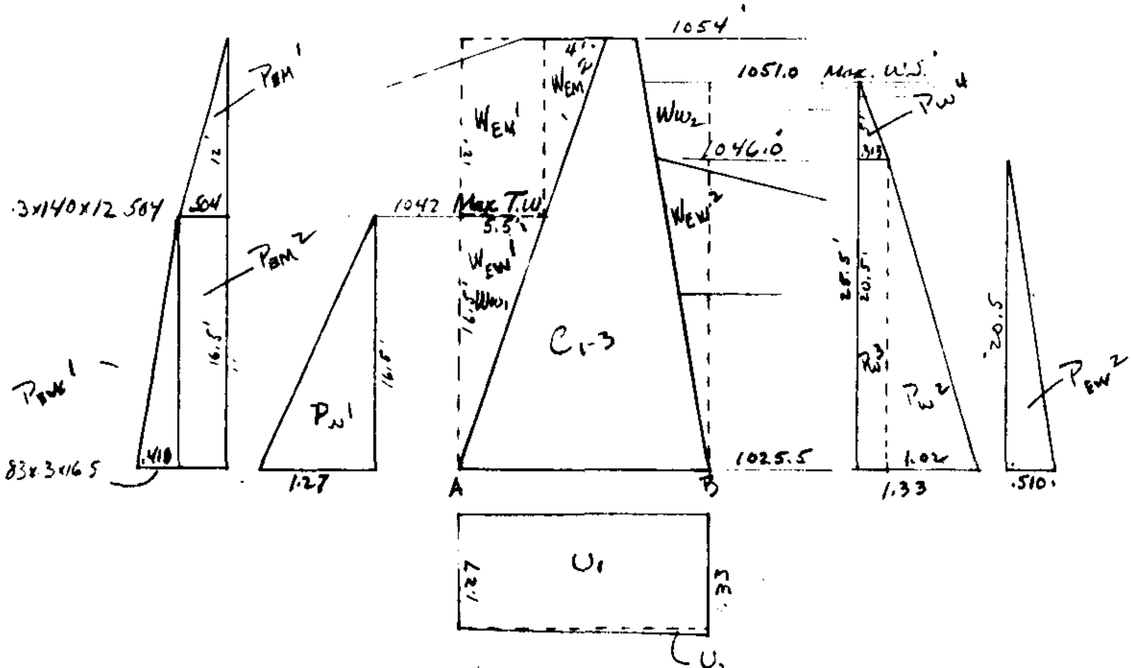
Seepage potential

			Position Potential
@ B	$\frac{82.87}{158.64} \times 9$	= 4.70'	16.5'
@ A	$\frac{66.62}{158.64} \times 9'$	= 3.78	16.5'

Effective hydrostatic pressure

@ B (4.70 + 16.5) .0625 = 1.33 K/sq ft.

@ A (3.78 + 16.5) .0625 = 1.27 K/sq. ft.



Effect of sloping fill neglected, answer on conservative side

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE DM-14

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)
COMPUTATION Wall · Stability
COMPUTED BY PDM CHECKED BY DATE

Moments about A

Item	Factors	Force	Arm	↶	↷
C_{1-3}		↓ 39.01	9.0		351.10
$W_{EM}1$	.14 x 5.5 x 12	9.24	2.75		25.41
$W_{EM}2$	.14 x .5 x 4 x 12	3.36	8.17		27.45
$W_{EW}1$	.083 x .5 x 5.5 x 16.5	3.77	1.83		6.89
$W_{EW}2$	.083 x .5 x 18.79 x 6.83 (20.5, 3.42)	5.33 (2.94)	~~13.07~~ 15.11		69.61 (43.96)
U_1	1.27 x 16.25	↑ 20.64	8.13	167.80	
U_2	.06 x .5 x 16.25	.49	10.83	5.31	
$P_{EM}1$	.5 x .504 x 12	→ 3.02	20.50		65.02 (61.95)
$P_{EM}2$	.504 x 16.5	8.32	8.25		68.61
$P_{EW}1$	.411 x .5 x 16.5	3.39	5.50		18.65
$P_{W}1$	1.29 (1.03) x .5 x 16.5	10.48	5.50		57.64 (46.77)
$P_{W}4$	- .313 x .5 x 5	← .78	22.17	17.35	
$P_{W}3$	- .313 x 20.5	6.42	10.25	65.77	
$P_{W}2$	- 1.02 (1.27) x .5 x 20.5	10.46	6.83	71.44	
$P_{EW}2$	- .51 x .5 x 20.5	5.23	6.83	35.70	
$W_{W}1$	5.5 x 16.5 x .5 x .0625	↓ 2.84	1.83		5.19
$W_{W}2$	.0625 x 4.25 x 23.5 x .5	↓ 3.31	14.83		50.2

21.70 (vertical down) 21.13 (vertical up) 25.21 (horizontal →) 22.89 (horizontal ←)

$\Sigma V = 43.38$ $\Sigma M = 319.87$

$\frac{H}{V} = \frac{2.34}{43.38} = .05$ $\Sigma H = 2.34$ $\frac{\Sigma M}{\Sigma V} = \frac{319.87}{43.38} = 7.37$ $e = -.75$

$$P = \frac{V}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{43.38}{16.25}\left(1 \pm \frac{6 \times .75}{16.25}\right)$$

$P = 3.41 \quad 1.93$

SUBJECT Mohawk River Ice Barrier (N.H.)
COMPUTATION Fish Ladder
COMPUTED BY PDM CHECKED BY [illegible] DATE 3/12/64

Section taken 25' downstream from ℄ dam.

Creep dist. is the same as for gravity wall except 4' shorter. Seepage --

Creep distance

$3+58.75+12.02+2+16.25+62.62 = 154.64$

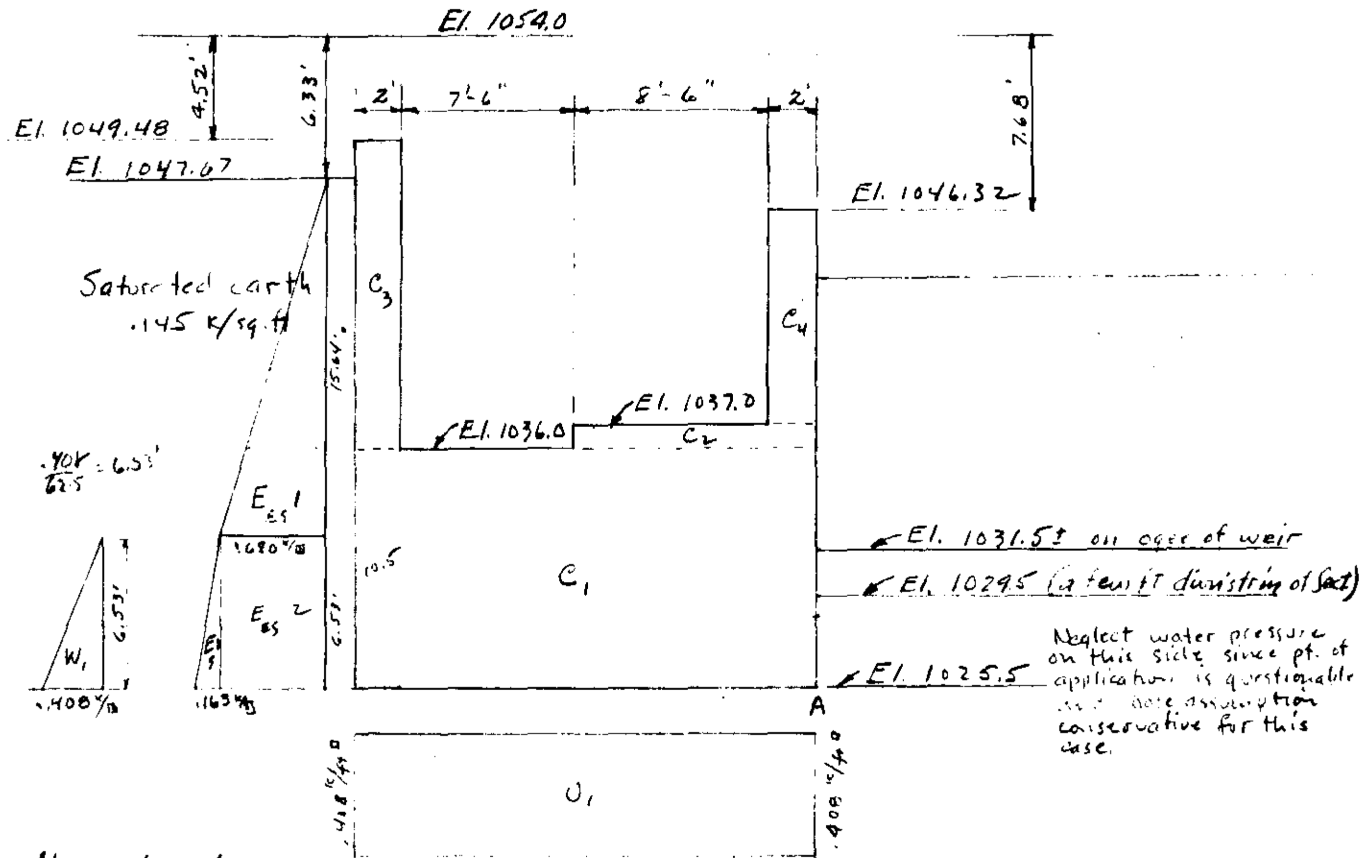
Net head = 7.5'

Seepage potential — Position potential

@ Sect $\frac{66.62+16.25-4.75-1-25}{154.64} \times 7.5 = 2.53$ — 4

Effective hydrostatic pressure

@ Sect. $(2.53+4)\,62.5 = 408.1 = .408$ k/sq. ft.



Mom. about A

Item	Factors		Force	Arm	↶	↷
C_1	20'× 10.5'× .15'	39.38 ↓	31.5	10'	315.00	
C_2	10.5'× 1'× .15'		1.58	5.25'	8.27	
C_3	2'× 11.64'× .15'		3.50	19'	66.52	
C_4	2'× 9.32'× .15'		2.80	1'	2.80	
$E_{ES}1$	→ .5 × .68 × 15.64	11.62 →	5.32	11.74		62.43
$E_{ES}2$	→ .68 × 6.53		4.44	3.27		14.52
E_s	→ .5 × .163 × 6.53'		.53	2.16		1.15
W_1	→ .5 × .408 × 6.53'		1.33	2.16		4.21
U_1	↑ .408 × 20'	↑	8.16	10'		81.60

$\Sigma M = 228.65$

$\frac{\Sigma H}{\Sigma V} = \frac{11.62}{31.22} = .37'$ O.K. $\frac{\Sigma M}{\Sigma V} = \frac{228.65}{31.22} = 7.32'$ from A

SUBJECT Mohawk River Ice Barrier (Colebrook, N.H.)

COMPUTATION Fish Ladder

COMPUTED BY PDM CHECKED BY H. E.W. DATE 2/25/64

$e = \frac{20}{2} - 7.32 = 10 - 7.32 = 2.68$

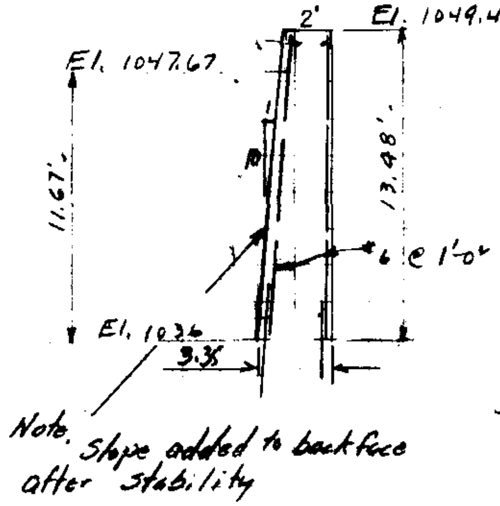
Within mid third

$p = \frac{V}{B}\left(1 \pm \frac{6e}{B}\right) = \frac{31.22}{20}\left(1 \pm \frac{6 \times 2.68}{20}\right) = 1.56(1 \pm .80) =$

$p = 2.81$ k/ft, $.31$ k/ft.

By inspection other conditions of stability are not critical

Reinforcing for wall section (C_3)



Moment-

$.5 \times .3 \times .145 \times \frac{11.67^3}{3} = 11.52$ 'k

$\frac{11.520 \times 12}{\times .885 \times 19} = .41$ in²/ft.

$V = .5 \times .3 \times .145 \times 11.67^2 = 2.96$ k

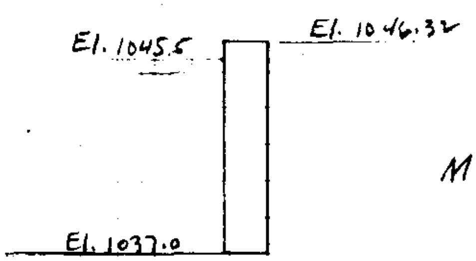
$v = \frac{V}{bjd} = \frac{2960}{12 \times .885 \times 19} = 14.7$ psi O.K

$u = \frac{V}{\Sigma_o jd} = \frac{2960}{2.356 \times .885 \times 19} = 74.7$ psi O.K

Use #6 @ 1'-0" c.c. in tension face.

Use #6 @ 1'-0" c.c. ea way, ea face.

Reinforcing in wall section (C_4):



Max water elev rt. side = 1035.0 ±

Max water elev left side = 1045.5'

Above cond. with full spillway discharge (7' surcharge)

$M = .0625 \times \frac{8.5^3}{3} \times .5 = 6.40$ 'k

Not critical

Use #6 @ 1'-0" ea. way, ea. face.

APPENDIX F

RECREATION

TABLE OF CONTENTS

APPENDIX F

RECREATION

1. DESCRIPTION

a. General

This Appendix presents data to supplement the section of the main report relating to recreation and the development of facilities. Contained herein is a description of existing recreational developments in the area, potential of project resources to meet recreational needs of the area, and specific data on proposed recreational development of the project. Consideration has been given to the characteristics of population of the area, potential inherent in tourism in northern New Hampshire, accessibility and economic justification of recreational development. Studies indicate that lakes located within a 25-mile radius of the proposed Colebrook dam site are not as suitable for recreational development as proposals recommended for the Mohawk River project site, and that costs for alternate recreational development are greater than for the recommended plan.

b. Pertinent Data

The Colebrook Ice-Retention Dam will maintain a 14-acre permanent pool with the prime purpose of creating and retaining a permanent lake of sheet ice to prevent spring ice flows from creating ice jam flooding in the built-up section of the Town. The permanent pool, which will be maintained year round, has an overflow spillway at elevation 1,044 feet, mean sea level, and at that elevation, a length of approximately 3,200 feet, a maximum width of 850 feet, and a maximum depth of 11 feet, affording an opportunity for a "project-related" recreational development during the summer season. The shoreline of the pool will be generally steep and well forested with an area in the upstream end well suited for recreational development.

c. Potential Sites for Recreational Development

(1) Existing Lakes Within 10 Miles

There are fifteen lakes and ponds within a 10-mile radius of Colebrook, New Hampshire, as noted on Table F-1, two of which have been developed for recreation by private interests (Lake Gloriette and Lake Abeniki) and five others which are smaller than 14 acres. The remaining eight lakes are, for the most part, undeveloped, and not readily accessible. They range in size from about 15 acres to 220 acres.

TABLE F-1

Lakes Within 10-Mile Radius of Colebrook Dam

	Water Body	Water Surface Area (Acres)	Pertinent Features
1.	Nash Bog Pond	223	Private boat launch site. 10 miles unimproved road.
2.	Diamond Pond	179	Approx. 23 bldgs. along waterfront. Municipal boat launch sites and commercial boat ramp.
3.	Little Diamond Pond	53	Coleman State Park. Commercial & State boat ramps.
4.	Mud Pond	43	Trail access - undeveloped.
5.	Lake Gloriette	31	Privately developed by Balsam Hotel.
6.	Clarksville Pond	25	Commercial & municipal boat ramps. 1.5 mile unimproved road from highway.
7.	Back Pond	22	Limited access. Municipal boat launch site. 0.2 miles unimproved road from highway.
8.	Fish Pond(1)	20	Commercial boat launch site. 0.1 mile unimproved road from highway.
9.	Lake Abenaki	18	Privately developed by Balsam Hotel.
10.	Lime Pond	12	Limited access. Municipal boat launch site 0.7 miles trail access.
11.	Lombard Pond	10	No access.
12.	Ladd Pond	10	Limited access.
13.	Matthews Pond	5	No access.

TABLE F-1 (Cont'd)

	Water Body	Water Surface Area (Acres)	Pertinent Features
14.	Cranberry Pond Bog	5	No access.
15.	Bear Rock Bog	5	No access.

NOTE: Lakes and ponds in Canada have not been included and all water bodies are located in New Hampshire unless otherwise noted.

(1) Considered most suitable as an alternate site.

Nash Bog Pond, the largest in this group, is on the outer limit of the 10-mile radius, but being located in the higher mountains surrounding the Mohawk River valley, it is actually a 40-mile roundabout drive from Colebrook. The last ten miles to the pond are over an undeveloped dirt roadway along the side of the Nash Stream. Diamond Pond with a surface area of 179 acres and Little Diamond Pond (53 acres) are the second and third largest lakes within the 10-mile radius. Situated about 10 miles northeast of Colebrook, they are headwater ponds for the Swift Diamond River which is in the Androscoggin River Watershed. Diamond Pond has been developed by commercial and municipal interests along that portion of its accessible shoreline. An additional 1/2-mile of access road would be required to reach the undeveloped shoreline. Existing access to both these ponds is classified as "light-duty" for about 3 miles. Coleman State Park on Little Diamond Pond has been developed for picnicking and swimming. The smaller ponds; Mud, Back, Lime, and Clarksville vary in size from about 15 to 45 acres and are generally swampy areas with no direct access. Extensive mud excavation and beach fills would be needed to develop these sites.

Fish Pond is considered most attractive of the alternate sites available, and is described in detail in Paragraph 4.

(2) Lakes Within 15 Miles

There are 22 ponds and lakes outlined in Table F-2 which are outside of a 10-mile radius, but within a 15-mile radius from Colebrook. Five are less than 14 acres in area. Lake Francis, the largest with a surface area of over 1,600 acres, is utilized as a power resource, and as such has limited recreational potential although it does have some existing State and commercially developed boating facilities. The remaining ponds, with the exception of Back Lake (359 acres) require costly access roads or are much further from Colebrook by roundabout routes than the 15-mile distance would indicate. Back Lake is located 15 miles north of Colebrook and 2 miles north of Pittsburgh, New Hampshire, and has been developed by the local municipality of Pittsburgh for swimming, boating, and picnicking. Although it can be reached directly by State Route 3 from Colebrook, access into the area is over a 2-1/2 mile unimproved road.

TABLE F-2

Lakes Within 15-Mile Radius of Colebrook Dam

	Water Body	Water Surface Area (Acres)	Pertinent Features
1.	Lake Francis	1,684	Man-made power reservoir. State & commercial boat ramp.
2.	Averill Lake, Vt.	840	One shore developed.
3.	Wallace Pond, Vt.	500	Vt. shore developed.
4.	Little Averill Lake, Vt.	475	No access.
5.	Back Lake	359	Local picnicking, swimming, boating. Commercial & municipal boat ramps. 2.5 miles unimproved access road.
6.	Millsfield Pond	160	Undeveloped.
7.	Dennis Pond, Vt.	80	Limited access.
8.	Trio Ponds	86	Undeveloped.
9.	Forest Lake, Vt.	60	One shore developed.
10.	Lewis Pond, Vt.	60	No access.
11.	Wheeler Pond, Vt.	60	Limited access - undeveloped.
12.	Phillips Pond	56	Limited access - 2 bldgs. on waterfront.
13.	Stratford Bog Pond	31	Several bldgs. near pond.
14.	Nathan Pond	31	No access.
15.	Little Bog Pond	20	Limited access.

TABLE F-2 (Cont'd)

	Water Body	Water Surface Area (Acres)	Pertinent Features
16.	Whitcomb Pond	18	No access.
17.	Tuttle Pond, Vt.	15	No access.
18.	Bragg Pond	10	Limited access.
19.	Carr Pond	10	No access.
20.	Little Pond	5	Limited access.
21.	Sugarloaf Pond	5	No access.
22.	Middle Pond	5	No access.

NOTE: Lakes and ponds in Canada have not been included and all water bodies are located in New Hampshire unless otherwise noted.

(3) Lakes Within 20 Miles

Outside of the 15-mile radius, but within 20 miles of Colebrook are located 26 ponds and lakes shown on Table F-3. Seven of these are smaller than 14 acres. The largest is the First Connecticut Lake which has a surface area of about 2,800 acres, and is one of three headwater lakes of the Connecticut River presently being developed by the New England Power Company. It supports some State and commercially developed boating and picnicking facilities.

Maidstone Lake, Vermont (750 acres), is a part of the Vermont State Forest and has moderate development for swimming and picnicking. Vermont authorities report that these facilities are being crowded to beyond their expected capacities. Other areas of the lake have extensive private development around the perimeter.

Norton Pond, Vermont (630 acres), is a privately-owned pond and can be reached by a roundabout route from Colebrook. Island Pond, Vermont (600 acres), which is more directly accessible is surrounded by private homes affording little opportunity for public recreation at realistic costs. Other ponds including Akers (270 acres), Greenough (240 acres), Dummer (117 acres), McConnel (90 acres), and Christene Lake (185 acres) cannot be reached directly from Colebrook, and require the construction of lengthy access roads over steep terrain. Seven other ponds with areas of about 25 acres would also require access roads through undeveloped woodland.

TABLE F-3

Lakes Within 20-Mile Radius of Colebrook Dam

	Water Body	Water Surface Area (Acres)	Pertinent Features
1.	First Conn. Lake	2,807	State boat ramp.
2.	Maidstone Lake, Vt.	750	2 commercial boat ramps (one with picnic site)
3.	Norton Pond, Vt.	630	Few bldgs. on waterfront.
4.	Island Pond, Vt.	600	Extensively developed.
5.	Akers Pond	309	Municipal & State boat ramps 0.2 mile access road.
6.	Greenough Pond	253	Limited access.
7.	Christene Lake	170	Few bldgs. on waterfront.
8.	Spectacle Pond, Vt.	120	Limited access.
9.	Dummer Ponds	150	No access.
10.	McConnel Pond, Vt.	90	
11.	Round Pond	62	Unimproved access 2 miles. Municipal boat launch site.
12.	West Mtn. Pond, Vt.	60	No access.
13.	Munn Pond	43	No access.
14.	Long Pond	37	Unimproved access - .1 mile. State boat launch site.
15.	Moose Pond	37	No access.
16.	Sessions Pond	36	No access.
17.	South America Pond, Vt.	30	No access.
18.	Mulhegan Pond, Vt.	20	
19.	Pike Pond	11	1 mile unimproved road. Municipal boat ramp.

TABLE F-3 (Cont'd)

	Water Body	Water Surface Area (Acres)	Pertinent Features
20.	Bear Brook Pond	10	No access.
21.	Lamb Valley Pond	10	No access.
22.	Beecher Pond	10	No access.
23.	Mile Pond, Vt.	10	No access.
24.	Unknown Pond, Vt.	10	No access.
25.	Notch Pond, Vt.	10	No access.
26.	Dutton Pond, Vt.	10	No access.

NOTE: Lakes and ponds in Canada have not been included and all water bodies are located in New Hampshire unless otherwise noted.

(4) Lakes Within 25 Miles

There are 17 ponds outside of the 20-mile radius, but within a 25-mile radius of Colebrook as shown on Table F-4. Five of the ponds provide a surface area of 14 acres or less. The two largest lakes are located on the Maine - New Hampshire state line in the Androscoggin River Basin. They are Umbagog (7,850 acres - 7 miles long) and Aziscohos (5,000± acres). One end of Lake Umbagog might be developed for recreation as it is located on New Hampshire State Route 26, but it is questionable as to the amount of usage it would accommodate due to its distance from any population center. The National Park Service recognizes the potential of this site as they have recommended it as a possible future parkland. Lake Aziscohos is inaccessible. Ten other ponds in this group are too distant from any population center and can be reached only by roundabout routes from Colebrook.

TABLE F-4

Lakes Within 25-Mile Radius of Colebrook Dam

	Water Body	Water Surface Area (Acres)	Pertinent Features
1.	Umbagog Lake	7,850	7 miles long. Access to one end only.
2.	Aziscohos Lake, Me.	5,000	No access.

TABLE F-4 (Cont'd)

	Water Body	Water Surface Area (Acres)	Pertinent Features
3.	Seymour Lake, Vt.	1,430	Extensively developed with private homes & cottages.
4.	Second Conn. Lake	1,286	State picnic site. Commercial boat ramp and Corporation boat ramp.
5.	Sturtevant Pond, Me.	540	No access.
6.	Holland Pond, Vt.	340	Limited access - few bldgs. on waterfront.
7.	South Pond	123	Limited access. Federal swimming, picnicking area. 2.0 miles surfaced road.
8.	Cedar Pond	78	Few bldgs. on waterfront.
9.	Center Pond, Vt.	40	Undeveloped.
10.	Beaver Pond, Vt.	30	No access.
11.	Big Brook Bog	20	No access.
12.	Jobs Pond, Vt.	20	Undeveloped.
13.	Turtle Pond, Vt.	15	No access.
14.	Halfway Pond, Vt.	15	No access.
15.	Round Pond, Vt.	15	No access.
16.	Beck Pond, Vt.	5	No access.
17.	Walker Pond, Vt.	5	No access.

NOTE: Lakes and ponds in Canada have not been included and all water bodies are located in New Hampshire unless otherwise noted.

d. Climate

The summer season is pleasant with an average temperature around 65° in July and August with frequent periods of hot days during these months. The average annual precipitation is approximately 41 inches for the watershed, with a mean annual snowfall of 102 inches.

2. FACTORS AFFECTING RECREATION DEVELOPMENT

a. Population Characteristics

The 1960 population figures show 14,600 (1) people residing within 25 miles of the project, an increase of 3.4 percent since 1950. Within a 50-mile radius of the project, there are 100,000 (1) people. Residents within a 25-mile radius of the project are mostly rural in nature having an average family income of less than $5,300.

b. Accessibility

The project at Colebrook is readily accessible by north-south U. S. Route 3 and east-west by State Route 26. Route 3 is heavily travelled by tourists as it passes through the popular White Mountain National Forest, a year-round recreational attraction. U. S. Route 3 linked with Interstate 93 makes the Colebrook area within a 4-hour drive of Metropolitan Boston.

c. Recreational Attractions of Area

The most prominent recreational attraction in northern New Hampshire is the White Mountain National Forest. Year-round activities of the area include hunting, fishing, hiking, picnicking, camping, sight-seeing, skiing and snowshoeing. The scenic charm of the White Mountains is a perennial lure to tourists. Although this region of New England is spotted with many lakes, there is a significant lack of publicly owned water areas to satisfy desires of the heavy tourist travel in the area.

d. Existing Public Recreation Areas

Out of a total of 80 lakes within the 25-mile zone of influence, only three are developed for general public recreation; namely, the South Pond recreation area managed by the National Park Service, Coleman State Forest Park managed by the New Hampshire Department of Parks, and Maidstone State Forest managed by the Vermont Department of Forests and Parks. These 3 areas have moderate development for picnicking and swimming. One area, Maidstone State Forest, has been developed to near saturation while the recently developed Coleman State Forest has room for limited expansion. The South Pond recreation area, developed in the early 1960's has additional area for expansion.

e. Tourism in the Area

Tourism, particularly in the summer and fall seasons, is heavy in northern New Hampshire with surveys reporting that visitation to the area has nearly doubled in the past decade. The area is well developed with motels, hotels and cottages for transient

(1) Excluding Canada

and vacation use. A 1963 survey by the State of New Hampshire revealed that 78% of visitors to New Hampshire State Parks were from out of state origin. During the summer the seasonal population within 25 miles of Colebrook increases by approximately 30 percent.

f. Suitability of Colebrook Project for Recreational Development

The upstream portion of the Colebrook Reservoir is suitable to practical recreational development, where approximately 10 acres of land is relatively flat and has a mature forest cover to support picnic groves. The shoreline of the pool in this upper end is suitable for beach development with a minimum of earthwork.

3. ANTICIPATED PUBLIC USE

a. Type Use Expected

It is expected that the primary use of the project will be limited to picnicking and swimming. The 14-acre water surface is too small for boating and access to it willbe confined to the proposed day-use development area. The surrounding northern New Hampshire area is a favorite area for hunting and fishing with abundant opportunities and it is not expected that the Colebrook project will offer any competition to the existing sportsman opportunities in the area.

b. Source of Visitation

A basic factor affecting visitation is the potential inherent in heavy out of state tourism. Approximately 80 percent of usage of the New Hampshire Park system is by out of state visitors. It is expected that many of the visitors passing through the area and staying at local hotels, motels and inns will take advantage of the opportunities of the project. It is anticipated that visitation in July and August will be equally divided between the population within a 25-mile radius and visitors from southern New Hampshire and out of state.

c. Estimated Visitation

A coordinated evaluation of the project by the Bureau of Outdoor Recreation and NED concluded that the ice dam would support an annual visitation of 13,000 people with ceiling limited to 18,000 due to physical characteristics of the land area.

4. FORMULATION OF ALTERNATE RECREATION SITE

Utilizing information available on USGS and AMS quad sheets (1:62,500) and data from the State of New Hampshire, Fish Pond, most likely existing alternate lake for recreational development in lieu of the Colebrook site was selected because of its proximity to the Town, its water surface area, and highway accessibility.

Fish Pond is located 4.5 miles south of Colebrook, New Hampshire. The pond has a water surface area of 20 acres at elevation 1,395 m.s.l. and a drainage area of about 2 square miles. There is an existing commercially owned boat launching site at one end of the pond. Further development at Fish Pond would require a one-tenth mile long access road from an existing light duty state road. Table F-5 indicates that the total project first cost for developing Fish Pond would be $224,000. The cost of the access road, selective clearing and beach development has been increased to reflect more extensive work and materials required to construct these facilities on undeveloped land. The construction of an earth dam and bottom discharge outlet works is estimated to cost about $100,000 and will afford greater pool depths and proper circulation.

Consideration has also been given to development of a single purpose recreation dam at the Colebrook site. The total comparative cost of a single purpose recreation dam and pool at the Mohawk River Dam site is estimated to be $386,000. However, since the Mohawk River Ice-Retention Dam requires a permanent pool, the only required specific cost for the recreation resource would be $49,700 as reported on Table 10 of the main report.

In summary, recreational development at alternate sites were found to be more costly and encountered the following problems:

(1) High cost of providing paved access roads over hilly, wooded terrain.

(2) Long indirect routes from town which would lower planned usage estimates.

(3) Poor circulation of water in ponds not having low flow outlets.

(4) Expense of removing mud and silt deposition from ponds.

(5) High cost of clearing wooded land.

(6) High cost of developed lake front properties.

TABLE NO. F-5

Detailed Cost Estimate

Fish Pond Development

Item	Quantity	Unit	Unit Price	Amount	Total
I. Facilities					
Access Road	1,000	L.F.	30.00	$ 30,000	
Parking Area	1	Job	L.S.	2,860	
Selective Clearing	5	Acres	600.00	3,000	
Drainage	1	Job	L.S.	4,400	
Beach Development	1	Job	L.S.	5,000	
Change House, Toilet	1	Job	L.S.	3,500	
Picnic Tables, Fireplaces	1	Job	L.S.	2,760	
				$ 51,520	
	Contingency			7,480	
					$ 59,000
II. Lands and Damages	6	Acres	100.00	$ 600	
	Contingency & Severance			400	
					$ 1,000
III. Dam and Outlet Works					
Site Preparation	1	Acre	500.00	$ 500	
Stream Control	1	Job	L.S.	7,000	
Earth Excavation	10,000	c.y.	1.00	10,000	
Earth Fill	18,000	c.y.	3.00	54,000	
Topsoil, Seeded	5,000	s.y.	1.00	5,000	
Stone Spillway	300	c.y.	6.00	1,800	
Bottom Discharge Outlet	1	Job	L.S.	6,500	
Miscellaneous	1	Job	L.S.	3,000	
				$ 87,800	
	Contingency			12,200	
					$100,000
	TOTAL DIRECT COST				$160,000
Indirect Costs					
Engineering & Design				$ 40,000	
Supervision & Administration				24,000	
	TOTAL INDIRECT COSTS				$ 64,000
	TOTAL PROJECT FIRST COST				$224,000

5. PLAN OF DEVELOPMENT

The Mohawk River recreation area will be developed for a design load of 350 visitors per day. Access will be provided to the area by extension of the construction access road to the dam, and a parking area for 75 cars will be provided. Both access road and parking area will be gravel surfaced with an oil penetration treatment. The area will have 24 picnic tables and 12 fireplaces located adjacent to a 4,000 square-yard sand covered beach area. An opened roofed change house and a pit type toilet, both of wood construction, will be located on high ground. The area could be expanded to accommodate a design load of 500 visitors if experienced use indicates the need. Expansion beyond that point would not be desirable.

6. ECONOMIC EVALUATION

a. Costs

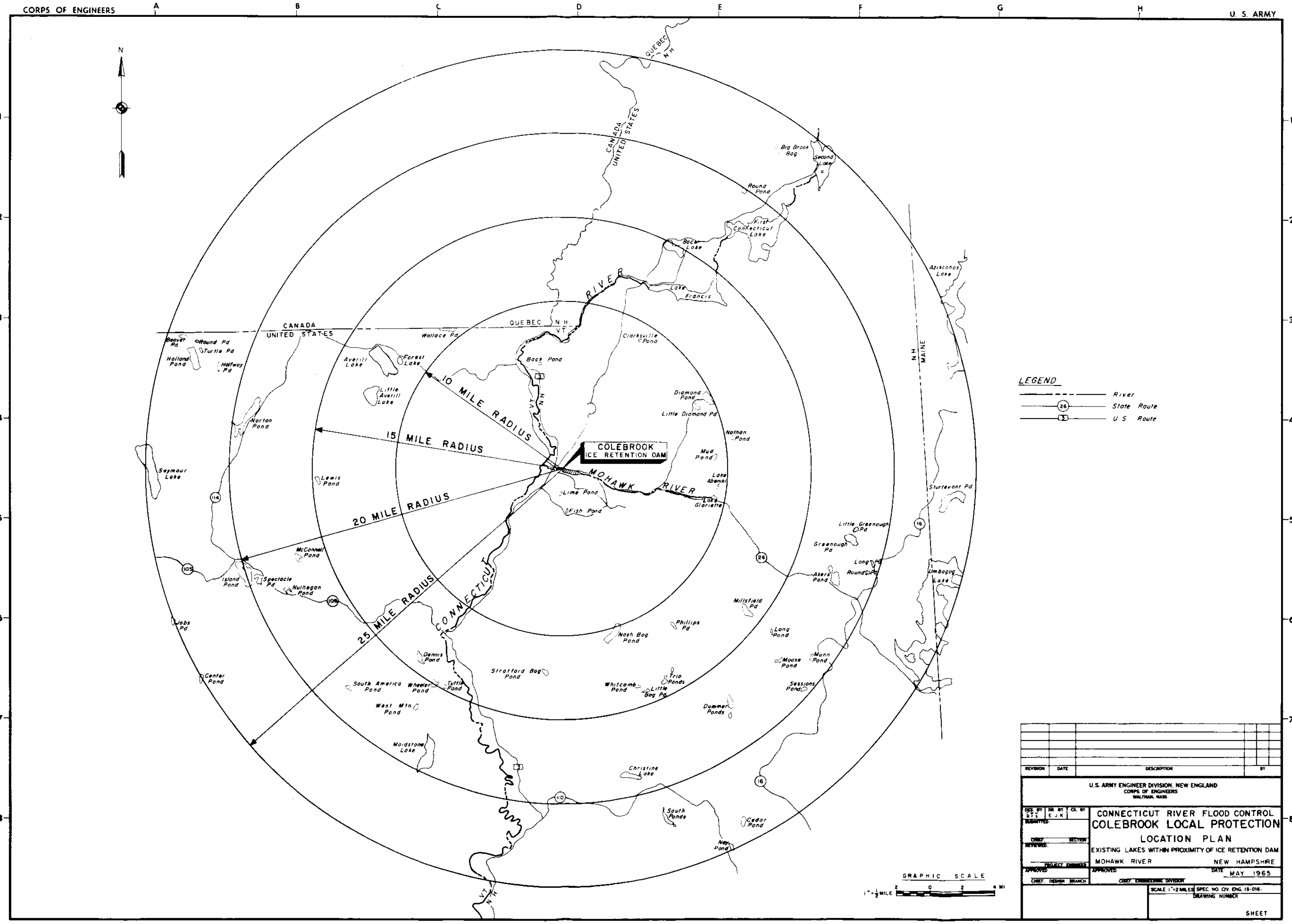
Shown below is the estimated cost of recreational development of the recommended project.

Item No.	Description	Quantity	Unit	Unit Price	Estimated Amount
1	Access Road	1,500	l.f.	12.00	$ 18,000
2	Parking Area	2,600	s.y.	1.10	2,860
3	Selective Clearing	5.	acre	300.00	1,500
4	Drainage - includes filling, grading to drain, and topsoiling low wet areas	8,000	s.y.	.55	4,400
5	Beach Development	4,000	s.y.	L.S.	2,630
6A	Change House	1	ea.	1,500.00	1,500
6B	Pit Toilet	1	ea.	2,000.00	2,000
7	Picnic Tables	24	ea.	85.00	2,040
8	Fireplaces	12	ea.	60.00	720
					$35,650
		Contingencies			5,350
		TOTAL			$41,000

Annual operation or maintenance is estimated at $1,500 which provides for one full-time summer employee, qualified in life saving, to manage the area. Another $500 is allocated to upkeep and replace facilities.

b. Benefits

Based on an annual visitation of 13,000 people annually and assuming a value of .75 per visitor day, the average annual recreation benefit is $9,750. In keeping with water resource planning to maximize water resource potential, and in view of the fact that a permanent pool is required to solve the ice problem which offers an opportunity for a "project-related" recreational development, the multi-purpose ice project as recommended can satisfy this need at a minimum cost.



CORPS OF ENGINEERS
U. S. ARMY
N
QUEBEC
N H
CANADA
UNITED STATES
CANADA
UNITED STATES
QUEBEC
N H
VT
Big Brook Bog
Second Lake
Round Pond
First Connecticut Lake
Back Lake
Lake Francis
RIVER
Aziscohos Lake
N H
MAINE
Beaver Pd.
Round Pd
Turtle Pd
Holland Pond
Halfway Pd
Wallace Pd.
Averill Lake
Forest Lake
Little Averill Lake
Clarksville Pond
Back Pond
Diamond Pond
Little Diamond Pd
Nathan Pond
Mud Pond
Lake Abenaki
Lake Gloriette
Norton Pond
Seymour Lake
Lewis Pond
10 MILE RADIUS
15 MILE RADIUS
20 MILE RADIUS
25 MILE RADIUS
COLEBROOK
ICE RETENTION DAM
MOHAWK
RIVER
Lime Pond
Fish Pond
LEGEND
River
State Route
U S Route
Sturtevant Pd.
Little Greenough Pd
Greenough Pd
Long Pd
Round Pd
Akers Pond
Umbagog Lake
McConnell Pond
Island Pond
Spectacle Pd
Nulhegan Pond
CONNECTICUT
Millsfield Pd
Phillips Pd
Long Pond
Nash Bog Pond
Jobs Pd.
Dennis Pond
Munn Pond
Moose Pond
Center Pond
South America Pond
Wheeler Pond
Tuttle Pond
Stratford Bog Pond
Whitcomb Pond
Trio Ponds
Little Bog Pd
Sessions Pond
West Mtn. Pond
Dummer Ponds
Maidstone Lake
Christine Lake
South Ponds
Cedar Pond
Nay Pond
VT
N H
GRAPHIC SCALE
1" = 1/2 MILE
2 0 2 4 MI
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
DES. BY C W H W F S
DR. BY E J K
CK. BY
SUBMITTED:
CHIEF, SECTION
REVIEWED:
PROJECT ENGINEER
APPROVED
CHIEF, DESIGN BRANCH
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK LOCAL PROTECTION
LOCATION PLAN
EXISTING LAKES WITHIN PROXIMITY OF ICE RETENTION DAM
MOHAWK RIVER
NEW HAMPSHIRE
APPROVED
CHIEF, ENGINEERING DIVISION
DATE MAY 1965
SCALE 1" = 2 MILES
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. F-1